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**(54) A seating system and a passenger accommodation unit for a vehicle**

(57) A seating system for a passenger vehicle, particularly an aircraft, comprising a plurality of seat units (40), each seat unit (40) defining a notional longitudinal seat axis (C-C) and comprising a supporting structure (42) adapted for attaching the seat unit to a floor (30) of a vehicle (12) and means forming or being configurable for forming a seat comprising a seat-pan (71) and a back-rest (72), said seat units (40) being arranged to form a column (29) defining a notional longitudinal column axis (B-B), in which column said seat-units (40) are arranged side-by-side in longitudinally offset relation at an acute angle to a notional column axis, thereby defin-

ing a space (36) to the rear of each seat, each seat unit (40) further comprising means forming or being configurable for forming a substantially flat bed (47,48,57,74,76), a major proportion of which bed is disposed forwardly of the position of the seat, which bed extends rearwardly into said space (36) to extend the flat-bed. Each seat unit may include a passenger supporting element (47) in said space to the rear of the seat, which passenger supporting element forms part of said flat bed. Said acute angle is preferably in the range 30 - 60°.

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## Description

[0001] The present invention relates to a novel seating system for a passenger vehicle, particularly an aircraft.

[0002] A conventional passenger seat for an aircraft comprises a back-rest and a seat-pan that are supported off the floor of the vehicle by means of a suitable supporting structure that is anchored to a pair of seat tracks in the floor. The seat defines a notional longitudinal seat axis, as viewed from the perspective of a passenger using the seat, and a plurality of such seats are adapted to be arranged in rows in a passenger accommodation cabin within the fuselage of an aircraft, each row extending transversely across the cabin, one behind another, with the notional seat axis of each seat substantially aligned with the longitudinal axis of the fuselage such that each seat faces forwards. Usually, the back-rest of the seat is capable of reclining from an upright position to a reclined position for the comfort of a passenger using the seat during the course of a flight. Some prior art passenger seats, particularly seats for use in business-class and first-class of sections of aircraft, where the pitch between adjacent rows of seats is greater than in an economy-class cabin, also comprise a leg-rest which is hinged to the front of the seat-pan and is capable of movement between a lowered or stowed position, in which the leg-rest depends from the seat-pan generally vertically towards the floor, and a raised or deployed position in which the leg-rest extends forwardly of the seat-pan to bear the passenger's legs off the floor. Thus, it is possible with conventional aircraft passenger seats to obtain a fair degree of comfort by reclining the back-rest and elevating the leg-rest, when fitted.

[0003] Whilst the above-described arrangement of conventional aircraft passenger-seats is generally satisfactory for short-haul flights having a duration of up to three or four hours, it is not satisfactory for use on longer flights during which passengers typically wish to go to sleep. Even in the reclined position described above, a passenger using the seat remains in a general sitting position. Many passengers find it difficult to sleep properly, if at all, when sitting. In recent years there has been a significant increase in the number of passengers who regularly make long-haul flights, and there has been a trend in the art to devise passenger seats which allow passengers to adopt further reclined positions during the course of a flight to facilitate sleeping. This is particularly important for passengers who travel for business purposes for whom it is desirable that they arrive at their destinations feeling refreshed and alert.

[0004] One possibility that has been disclosed in the art for increasing the degree to which an aircraft passenger seat can be reclined comprehends simply increasing the extent to which the back-rest can be reclined backwards and the leg-rest elevated. In the extreme, it is possible to form a substantially flat bed using such a technique in which the back-rest is reclined and

the leg-rest raised, each to such an extent that they are disposed substantially co-planarly with the seat-pan and each other. A disadvantage of such a system is that the pitch between adjacent rows of seats must be increased substantially to accommodate the full height of a passenger. Whilst this is sometimes possible in the first-class area of an aircraft cabin, it is generally uneconomic for a business-class cabin. Furthermore, whilst it is possible to form a generally flat surface which is disposed substantially horizontally, the surface is still not ideal, because the foam or other padding on the seat is generally sculptured for use as a seat, whereas for a bed, it is desirable to have a substantially flat surface.

[0005] GB 2326824 A discloses a seating unit for a first class aircraft cabin comprising a secondary seat positioned to face a primary seat, the secondary seat having a seating portion positioned to cooperate with a leg-rest of the primary seat to form a continuous, flat sleeping surface when the back-rest of the primary seat is reclined to a horizontal position. The seating unit defines a notional, longitudinal seat axis, and a plurality of such seating units may be arranged within the cabin side-by-side in a longitudinally offset relation with respect to the longitudinal axis of each seat, with each seating unit being oriented at an acute angle to the longitudinal axis of the aircraft fuselage, so as to define a generally triangular or trapezoidal space to the front or rear of each seating unit (according to whether the seating units face outwards or inwards relative to the cabin). The space is used to accommodate a counter-top to one side of an adjacent seating unit and optionally a cupboard or other storage space. The seating unit of GB 2326824 A has the advantage that by incorporating an additional, secondary seat in the flat sleeping surface together with back-rest, seating portion and leg-rest of the primary seat, it is possible to form a long sleeping surface which is able to accommodate comfortably passengers having a height of greater than 6ft (1.83m). However, the seating unit of GB 2326824 A represents an even greater overhead in terms of cabin space than the conventional system described above and, moreover, still suffers from the disadvantage that the seat cushioning is designed principally for use as a seat and not a bed. A disadvantage of the seat of GB 2326824 A is that it occupies a very large floor area within the cabin and, in view of its overall length, the seating unit of GB 2326824 A is wholly unsuitable for use in a business-class section of an aircraft.

[0006] WO 00/21831 A2 discloses a seating unit which can be converted into a bed for use principally in a business-class section of aircraft cabin. The seating unit of WO 00/21831 A2 comprises a pair of seats facing in opposite directions, each seat comprising a seating space for the seated body of an occupant and an extension space in which the legs of an occupant may be placed. The seats are positioned each side of a notional dividing axis with the seating space of one extending over the axis into the extension space of the other. When

installed in an aircraft cabin, one of the seats faces substantially forwards and the other faces substantially aft. Each seat of the seating unit of WO 00/21831 A2 comprises a primary seat that is substantially the same as the primary seat of GB 2326824 A described above, but without a leg-rest, and a secondary unit spaced forwardly of the primary seat. Each seat thus comprises a primary seat having a reclinable back-rest and seat-pan and a secondary unit comprising an elevated pad which serves as a foot-rest. The primary seat can be reclined such that as the back-rest is reclined, the seat-pan moves forwardly to meet the secondary unit to form a continuous surface therewith which serves as a sleeping surface for a passenger. As with GB 2326824 A, the seating unit of WO 00/21831 A2 therefore has the advantage of providing a substantially horizontal sleeping surface for a passenger during long-haul flights. However, the seating unit of WO 00/21831 A2 is still extravagant in terms of the space available within a typical business-class cabin and also suffers from the disadvantage that when configured as a bed, each seat is unable to accommodate comfortably tall passengers. As with the other prior art seats described above, each of the seats of the seating unit of WO 00/21831 A2 also suffers from the disadvantage that the seat cushioning is not specifically designed for use as a bed surface, but is contoured for use principally as a seating surface.

[0007] Another attribute of a passenger seat for use in a first-class aircraft cabin is a generous seat width. A further disadvantage associated with the seating unit of WO 00/21831 A2 is that in order to accommodate a maximal head count within a business class cabin, the seat width is reduced, which many passengers find to be uncomfortable. Whilst the seating unit of WO 00/21831 A2 has the undeniable benefit of providing a substantially flat sleeping surface for a passenger in-flight, its overall dimensions are such that passengers of above average height and/or weight find the accommodation somewhat cramped. Furthermore, privacy screens are provided between adjacent seating units which, in combination with the total number of seating units provided in the limited space afforded by a business class cabin, result in the cabin as a whole having a somewhat crowded appearance.

[0008] JP 5-13838 A discloses a seating system for vehicles such as buses and trains comprising a plurality of seats. Each seat comprises a seat-pan and a back-rest that can rock between an upright position and a reclined position, and the seats are positioned within a cabin at an angle with respect to a centre-line of the cabin and face outwardly to define a generally triangular space between each seat and a wall of the cabin. Said space accommodates a box comprising a foot-rest for an adjacent seat.

[0009] FR 647809 A discloses a seating system for a sleeping car in which a plurality of seats are arranged at an angle to the longitudinal axis of the sleeping car, facing inwardly to define a generally triangular space to

the rear of each seat which is used to accommodate a small table for an adjacent seat.

[0010] An object of the present invention therefore is to provide improved passenger accommodation for a business-class section of a passenger aircraft. In particular, it is an object of the invention to provide such accommodation which incorporates a flat sleeping surface of maximal length and preferably also of maximal width.

[0011] Another object of the invention is to provide an improved passenger accommodation unit for a vehicle, particularly an aircraft, which accommodation unit is adapted to provide self-contained, individual seating and sleeping accommodation for a passenger, particularly for use in the business-class section of an aircraft where the pitch between adjacent rows of seats is typically in the range of 50-60 inches (1.27 to 1.52 metres).

[0012] Yet another object of the present invention is to provide a passenger accommodation unit which can be converted into a bed having maximal length to accommodate tall passengers, particularly those having height greater than 6ft (1.83 metres).

[0013] Yet another object of the present invention is to provide a seating system for a passenger vehicle, particularly an aircraft, which optimises the use of space within a passenger cabin.

[0014] Yet another object of the present invention is to provide a seating system for a cabin of a passenger vehicle which has a substantially uncrowded appearance.

[0015] Further objects of the invention will be apparent to those skilled in the art from the following description of the invention and specific embodiments of the invention.

[0016] According to the present invention, there is provided a seating system for a passenger vehicle, particularly an aircraft, comprising a plurality of seat units, each seat unit defining a notional longitudinal seat axis and comprising a supporting structure adapted for attaching the seat unit to a floor of a vehicle and means forming or being configurable for forming a seat comprising a seat-pan and a back-rest; characterised in that said seat units are arranged to form a column defining a notional longitudinal column axis, in which column said seat-units are arranged side-by-side in longitudinally offset relation at an acute angle to the notional column axis, thereby defining to the rear of each seat, each seat unit further comprising means forming or being configurable for forming a substantially flat bed, a major proportion of which bed is disposed forwardly of the position of the seat, which bed extends rearwardly into said space to extend the flat-bed.

[0017] Preferably said space to the rear of each seat is generally triangular or trapezoidal. Said acute angle is typically in the range 30° - 60°, preferably 40° - 50°, e. g. 40°, 45° or 50°. Normally, the seat units are installed in an accommodation cabin of said vehicle, which cabin defines a notional longitudinal cabin axis. Said notional

column axis may be substantially parallel to or subtend an acute angle with said cabin axis. Thus, within an aircraft cabin, seat units according to the present invention may be positioned in a "herringbone" arrangement.

[0018] Said seat units may be disposed adjacent a side wall of the vehicle and face inwardly. Preferably, said accommodation cabin comprises two opposing side walls, and a column of seat units may be positioned contiguously or closely adjacent to each wall such that each seat faces into the cabin, with an extension surface behind the back-rest of the seat disposed adjacent the wall. The seats may thus have their backs to the vehicle wall, giving the cabin as a whole an uncrowded appearance.

[0019] Where cabin space permits, one or more additional columns of seat units may be provided towards the centre of the cabin. If it is possible to accommodate two central columns of seats in any given cabin, then preferably those columns are arranged generally back-to-back.

[0020] Preferably each seat unit further comprises a foot-rest that is positioned forwardly of the seat. Said foot-rest can thus be used by an occupant of the seat to support his or her feet in-flight in an elevated position and/or by another passenger to sit on whilst visiting the occupant. Provided that such a foot-rest is provided, it has been found that passengers do not require the seat unit to incorporate a movable leg-rest as part of the seat-forming means.

[0021] In some embodiments, each seat unit may further comprise a first privacy screen that is positioned forwardly of said foot-rest.

[0022] Said seat forming means and said bed forming means may comprise one or more movable passenger-bearing elements which are selectively configurable to form, in a seat mode, at least part of the seat for a passenger or, in a bed mode, at least part of said flat bed, and advantageously the flat bed in the bed mode is disposed at substantially the same level as the seat-pan in the seat mode.

[0023] Preferably, each seat unit comprises a first, preferably fixed, passenger-supporting element in said space to the rear of the seat, which first passenger-supporting element is disposed substantially coplanarly with said one or more movable elements when said movable elements are configured in the bed mode and is adapted to form part of said flat bed. Said first passenger-supporting element may be generally triangular or trapezoidal. It will be appreciated that the first passenger-supporting element is only used by a passenger when the seat unit is arranged in the bed configuration, and accordingly the seat unit may be arranged such that the first passenger-supporting element extends into a lateral recess defined by the concave cabin side wall to maximise the use of space in the cabin.

[0024] Advantageously, each seat unit further comprises a second, preferably fixed, passenger-supporting element to one side of the seat, which second passen-

ger-supporting element is disposed substantially coplanarly with said first passenger supporting element and is adapted to form part of said flat bed when the movable elements are configured in said bed mode, thereby to extend said flat bed laterally. Said second passenger-supporting element may be generally triangular or trapezoidal. Said first fixed element of one seat unit may be disposed substantially contiguously to the second fixed element of an adjacent seat unit, and said first and second elements may be divided from one another by a second privacy screen. Said first and second elements may occupy substantially all of the space to the rear of the seat.

[0025] The present invention thus provides a seating system which is particularly suited for a business-class cabin of a passenger aircraft. The seating system of the present invention provides individual seat units having back-rests and seat-pans and optional foot-rests to allow passengers to rest their legs in an elevated position during a flight. Each seat unit is provided with self-contained means for forming a substantially flat bed, and the use of space within the cabin is optimised by positioning the flat bed to extend rearwardly behind the seat into a space defined by the arrangement of the seat units. Surprisingly, it has been found that in accordance with the present invention it is possible to provide flat beds within a business-class section of a passenger aircraft having a length of up to 7m (2.13 metres) without substantially sacrificing head-count. Furthermore, the applicants have found that the seat units of the present invention can be positioned to give the cabin a substantially uncrowded appearance.

[0026] Said supporting structure may be manufactured from any suitable, aviation standard, lightweight material that is known to those skilled in the art and may be equipped with suitable anchoring means for anchoring the seat unit to seat tracks in an aircraft passenger cabin. Preferably, the supporting structure comprises a palette or plinth which is adapted to be attached to said seat tracks.

[0027] Advantageously, the seat unit may be oriented at an angle of between 35 and 55°, preferably 40 to 50°, relative to the longitudinal axis of an aircraft cabin such that an extension surface behind the back-rest element extends into a recess defined by a typical concave aircraft cabin interior wall. Whilst the area of the cabin juxtaposed the concave cabin wall is not suitable, and has insufficient headroom, to accommodate the back-rest element in the upright position, it can be used in accordance with the present invention to accommodate the rear extension surface which forms part of the bed surface in the bed configuration.

[0028] Following is a description by way of example only with reference to the accompanying drawings of embodiments of the present invention.

[0029] In the drawings:

FIG. 1 is a sectional, schematic plan view of a front

portion of an aircraft fuselage showing a seating system in accordance with the present invention comprising a plurality of individual seat units.

FIG. 1A is an enlarged view of part of FIG. 1 showing three adjacent seat units.

FIG. 2 is an isometric view of the three adjacent seat units of FIG. 1A. In FIG. 2, one of the seat units is shown in an upright seating configuration, another is shown in a reclined seating configuration, and the third is shown in a bed configuration.

FIG. 2A shows a portion of a supporting structure of an individual seat unit of the kind shown in FIG. 2, with the movable seat elements removed.

FIG. 3 is a schematic side elevation of a first passenger seat assembly for a vehicle, shown in an upright seating configuration.

FIG. 4 is another schematic side elevation of the first passenger seat assembly of FIG. 3, shown in a fully reclined seating configuration.

FIG. 5 is yet another schematic side elevation of the first seat assembly of FIGS. 3 and 4, shown in a bed configuration.

FIG. 6 is an isometric view of part of the first seat assembly of FIGS. 3 to 5 in the upright seating configuration, with the seat upholstery removed.

FIG. 6A is a side elevation of a back-rest component forming part of the first seat assembly of FIG. 6.

FIG. 6B is an isometric view of the back-rest component of FIG. 6A.

FIG. 7 is another isometric view of the part of the first seat assembly shown in FIG. 6, with the seat assembly in the fully reclined seating configuration.

FIG. 8 is yet another isometric view of the part of the first seat assembly of FIGS. 6 and 7, with the seat assembly in the bed configuration.

FIG. 9 is an isometric view of part of a seat movement mechanism of the first seat assembly of FIGS. 3 to 8, shown in the bed configuration.

FIG. 10 is a side elevation of the part of the seat movement mechanism of FIG. 9, shown in the seating configuration.

FIG. 11 is another side elevation of the part of the seat movement mechanism of FIGS. 9 and 10, shown in the bed configuration.

FIG. 12 is an enlarged isometric view of part of the seat movement mechanism of FIGS. 9 to 11.

FIG. 13 is an isometric view of part of a seat reclining sub-mechanism of the first seat assembly of FIGS. 3 to 8.

FIG. 14 is an isometric view of part of a seat conversion sub-mechanism of the first seat assembly of FIGS. 3 to 8, shown in the bed configuration.

FIG. 15 is another isometric view of the part of the seat conversion sub-mechanism of FIG. 14, shown in the seat configuration with a worm-screw removed from a corresponding worm-gear to allow manual movement of the seat conversion sub-mechanism between the seat and bed configura-

tions.

FIG. 16 is an enlarged, sectional side elevation of part of the seat conversion sub-mechanism of FIGS. 14 and 15.

FIG. 17 is a sectional, schematic plan view of another seating system in accordance with the present invention.

FIG. 18 is an isometric view of another accommodation unit shown in a seat mode.

FIG. 19 is an isometric view of the passenger accommodation unit of FIG. 18, shown in a bed mode.

FIG. 20A is a schematic, isometric view of the passenger accommodation unit of FIGS. 18 and 19, showing a passenger using the seat in the seat mode.

FIG. 20B is a schematic, isometric view of the passenger accommodation unit of FIGS. 18 and 19, showing a passenger using the seat in the bed mode.

FIG. 21 is an isometric view of a variant of the passenger accommodation unit of FIGS. 18 and 19, which comprises a sliding seat-pan.

FIGS. 22A-22C show schematically in side elevation different positions of the sliding seat-pan.

FIG. 23 is an isometric view showing a further variant of the passenger accommodation unit of FIGS. 18 and 19.

FIG. 24 is a schematic, sectional plan view of the upper and lower decks of a front portion of an aircraft fuselage, showing yet another seating system in accordance with the present invention as applied to the upper and main decks of a Boeing 747-400 aircraft.

[0030] A passenger aircraft generally comprises a hollow, spindle-shaped fuselage having a front end and a rear end. A front end portion 12 of a typical aircraft fuselage 10, which is disposed towards the front end 11, is shown in FIG. 1 of the accompanying drawings, by way of example. Said fuselage 10 defines a longitudinal aircraft axis indicated by the chain-dot-line A-A in FIG. 1 between the front and rear ends, and the fuselage 10 tapers towards the front end 11 to form a nose portion 15.

[0031] The fuselage 10 accommodates many of the functions and facilities of the aircraft, including one or more passenger accommodation cabins 20, 21. The number and size of the passenger cabins 20, 21 provided on a given aircraft depends on the space available within the fuselage for passenger accommodation and on the desired configuration of the passenger accommodation. The present invention is not limited to the use of any particular shape, size or number of passenger cabins. However, in FIG. 1, which is given by way of example only, two cabins 20, 21 are shown in the front portion of the fuselage 12, a first cabin 20 being located within the nose portion 15 of the aircraft, and a second cabin 21 being disposed behind the first cabin 20, with

a utilities area 22 being provided between the two cabins 20, 21. Said utilities area 22 may include a galley 23 and one or more passenger toilets 24 as shown in FIG. 1.

**[0032]** As shown in FIG. 1, an aircraft passenger cabin 20, 21 is generally defined by two opposing surface portions 26, 28 of the interior surface of the fuselage 10. Said opposing surface portions 26, 28, in effect, constitute opposing side walls of the cabin 20, 21. The cabin 20, 21 also comprises a floor or deck 30 which is supported by suitable infra-structure (not shown) within the fuselage and a ceiling (also not shown) that extends between the opposing side walls above the floor 30. Said opposing side walls 26, 28 are usually lined with a plurality of pre-fabricated, composite panels to give the interior of the cabin attractive appearance and to provide thermal insulation between the cabin 20, 21 and the outside of the aircraft.

**[0033]** Embedded within the floor 30, the infra-structure of the fuselage 10 comprises a plurality of pairs of seat tracks 32, 34 of the kind well known to those skilled in the art and indicated in FIG. 1 by dotted lines. Each seat track pair is substantially linear and comprises a pair of substantially parallel tracks for fixedly securing to the aircraft infra-structure a plurality of seats or other fixtures. Generally, an aircraft passenger cabin 20, 21 comprises two outer pairs of seat tracks 32, each being disposed adjacent a respective one of the two opposing cabin side walls 26, 28. Where space permits, a cabin 20, 21 may also include one or more central pairs of seat tracks 34 disposed intermediate the outer seat track pairs 32. As shown in FIG. 1, the first cabin 20 comprises a single central pair of seat tracks 34, whilst the second cabin 21 comprises two juxtaposed central pairs of seat tracks 34. Typically, a central seat track pair 34 extends substantially parallel to the longitudinal aircraft axis A-A. Where a passenger cabin 21 is positioned towards a central portion of the fuselage 10, away from the front and rear ends of the aircraft, such, for example, as the second cabin 21 in FIG. 1, the opposing side walls 26, 28 of the cabin 21 extend substantially parallel to the longitudinal axis A-A of the aircraft, and the outer seat track pairs 32 follow the line of the side walls 26, 28 and thus also extend substantially parallel to the longitudinal aircraft axis A-A. However, towards the nose portion 15 of the aircraft, the opposing side walls 26, 28 are arcuate and converge towards the front end 11. Accordingly, in such cases, the outer seat track pairs 32 are angled with respect to the longitudinal aircraft axis A-A to subtend an acute angle therewith.

**[0034]** Each cabin 20, 21 accommodates a plurality of seat units 40. As shown in FIG. 1, within each cabin 20, 21 the seat units 40 are arranged to form a plurality of columns 29 as described in more detail below. Each column 29 is fixedly secured to a respective pair of seat tracks 32, 34 and extends substantially parallel thereto to define a notional column axis indicated by the lines B-B in Fig. 1. As shown in Fig. 1, the first cabin 20 comprises two columns 29 of seat units 40, each of said col-

umns 29 being fixedly secured to a respective one of the outer pairs of seat tracks 32. As the outer pairs of seat tracks 29 in the first cabin 20 are inclined with respect to the longitudinal axis A-A of the aircraft, the notional column axis B-B of each of the columns 29 of seat units 40 in the first cabin also subtends an acute angle with the longitudinal aircraft axis A-A. The second cabin 21 comprises two outer columns 29 of seat units 40 and two mutually juxtaposed central columns 29 of seat units 40. Each of the outer columns 29 is attached to a respective one of the outer pairs of seat tracks 32, and each of the central columns 29 is attached to a respective one of central pairs of seat tracks 34. As described above, the central pair of seat tracks 34 extends substantially parallel to the longitudinal aircraft axis A-A, and accordingly each of the central columns 29 of seat units 40 also extends substantially parallel to the longitudinal aircraft axis A-A. In the second cabin 21, each of the outer pairs of seat tracks 32 also extends substantially parallel to the longitudinal aircraft axis A-A, and accordingly each of the outer columns 29 of the second cabin 21 extends substantially parallel to the aircraft axis A-A.

**[0035]** FIGS. 1A and 2 show three adjacent seat units 40 forming part of one of the columns 29 of FIG. 1. Each seat unit 40 comprises supporting structure 42 for attaching the seat unit to the floor 30. Said supporting structure 42 may be fabricated in any suitable manner known to those skilled in the art, but preferably comprises a load-bearing, aerospace grade steel sub-frame (not shown), clad with one or more shaped composite panels. Each seat unit 40 has a front end 51, a rear end 52 and two opposing sides 53, 54. Juxtaposed the rear end 52, the supporting structure 42 comprises a seat housing 43 as shown in FIG. 2A which defines a substantially cuboidal recess 44. To the rear of said recess 44, the supporting structure 42 defines a first, substantially flat, generally triangular surface 47 which, when the seat unit 40 is installed in a cabin 20, 21, extends generally parallel to the floor 30 of the cabin 20, 21, but at a slight incline thereto, as described in more detail below. Juxtaposed a first side 53 of the seat unit 40, the supporting structure 42 defines a second substantially flat, generally triangular surface 48 which is substantially co-planar with the first surface 47 and, in some embodiments, as shown in FIGS. 2 and 2A, may be substantially contiguous with the first surface 47. Each of said first and second surfaces 47, 48 is sufficiently strong to support at least part of the weight of a passenger. Said second surface 48 has a first concave lateral edge 45 which extends from a front end of the seat housing 43 outwardly and rearwardly to a point 46 intermediate the front end of the housing 43 and the rear end 52 of the seat unit 40. Said first and second surfaces 47, 48 define a substantially linear second lateral edge 49 which extends rearwardly and inwardly from said point 46 to the rear end 52 of the seat unit. Said first and second surfaces 47, 48 thus extend to the rear and one side

of the cuboidal recess 44 and define the upper extent of said recess 44. Said first and second surfaces 47, 48 are supported at a predetermined height off the floor 30 of the cabin 20, 21 by the supporting structure 42.

[0036] At the second side 54 of the seat unit 40, the seat housing 43 comprises an upstanding arcuate screen 60 having a convex rear portion 61 which extends from the rear end 52 of the seat unit 40 to a rear end of the cuboidal recess 44 and a generally linear front portion 62 which extends between the front and rear ends of the recess 44. Said rear convex portion 61 has a curvature in plan view as shown in FIG. 1A which corresponds to the curvature of the first concave lateral edge 45 of the second surface 48. Said screen 60 extends substantially higher than the first and second surfaces 47, 48 and serves as a privacy screen for a passenger using the seat unit 40, around the rear end 52 and second side 54 of the seat unit 40.

[0037] Juxtaposed the front end 51 of the seat unit 40, the supporting structure 42 comprises an ottoman which extends upwardly from the floor 30 and has a substantially flat upper surface 66. Said upper surface 66 is adapted to carry a cushion 67 having a thickness such that the cushion 67 is disposed substantially co-planarly with the first and second surfaces 47, 48. Said ottoman 65 is sufficiently strong to support the weight of a passenger such that the ottoman 67 can be used as an auxiliary seat if desired. Said supporting structure 42 further comprises a relatively small, auxiliary privacy screen 68 around the front end 51 of the seat unit 40.

[0038] Said cuboidal recess 44 receives a plurality of moveable passenger-bearing elements which are connected to the supporting structure by a seat movement mechanism described in more detail below. Said moveable passenger-bearing elements comprise a seat-pan 71 and a back-rest 72. The seat movement mechanism allows the passenger-bearing elements to be selectively configured to provide a seat for a passenger, as shown in the centre and right-hand seat units 40 of FIG. 2, or a bed as shown in the left-hand seat unit 40 of FIG. 2. In the seat configuration, the moveable passenger-bearing elements 71, 72 are selectively movable between an upright or dining position as shown in the right-hand seat unit 40 of FIG. 2 and a reclined or lounge position as shown in the centre seat unit 40 of FIG. 2.

[0039] Said moveable passenger-bearing elements 71, 72 are attached to the supporting structure 42 through the seat movement mechanism such that, in the seat configuration, the seat-pan 71 is accommodated within the cuboidal recess 44 of the housing 43, and the back-rest 72 extends upwardly from the recess 44 to the rear of the seat-pan 71 and extends transversely between the first and second sides 53, 54 of the seat unit 40. As perceived by a passenger using the seat unit 40, therefore, the seat unit 40 defines a notional longitudinal seat axis which extends between the front and rear ends 51, 52 of the seat unit 40 and is indicated in FIG. 1A by the dashed line C-C.

[0040] In the fully upright position, the seat-pan 71 is disposed substantially at the same level as the first and second surfaces 47, 48 of the housing 43 and is spaced rearwardly of the ottoman 65, such that the cushion 67 provides a foot-rest for a passenger using the seat unit 40. In the reclined position, the back-rest 72 is reclined rearwardly relative to its position in the upright position, and the seat-pan 71 is tilted slightly rearwardly to provide an ergonomically comfortable lounge seating position. Again, in the lounge position, the cushion 67 of the ottoman 65 provides a foot-rest for the passenger.

[0041] Said back-rest 72 comprises a front surface 73 and a rear surface 74. In the upright and reclined positions the front surface 73 of the back-rest cooperates with the seat-pan 71 to form the seat for the passenger. In the bed configuration, as shown in the left-hand seat unit of FIG. 2 the back-rest is rocked forwardly relative to the seat unit and is partly accommodated within the cuboidal recess 44 such that the rear surface 74 of the back-rest 72 is substantially co-planar with the first and second surfaces 47, 48 and with the cushion 67 of the ottoman 65. The rear surface 74 of the back-rest 72 is also substantially continuous with the second surface 48 and cushion 67 in the bed configuration. The seat movement mechanism includes a moveable infill element 76, as shown in FIG. 1A, which is moved from a stowed position to a deployed position when the seat is converted from the seat configuration to the bed configuration. In the bed configuration, the infill element 76 is disposed intermediate and substantially co-planarly and contiguously with the rear surface 74 of the back-rest 72 and said first surface 74. In the bed configuration, the seat unit 40 thus provides an extended bed surface for the passenger, the bed surface being extended rearwardly of the seat by the first surface 47, laterally of the seat by the second surface 48 and forwardly of the seat by the cushion 67 of the ottoman 65.

[0042] With reference to FIGS. 1 and 1A, the seat units 40 within each column 29 are attached to the respective pair of seat tracks 32, 34 such that the notional longitudinal seat axis C-C of each seat unit 40 subtends an acute angle with the notional longitudinal column axis B-B, and the seat units 40 are arranged side-by-side in longitudinally off-set relation to each other such that each seat unit 40 defines a generally triangular or trapezoidal space 36 to the rear of each seat 71, 72. Said seat units 40 are arranged within the column 29 such that the convex portion 61 of the privacy screen 60 of one seat unit 40 abuts substantially contiguously on the first concave lateral edge 53 of another adjacent seat unit 40. As best seen in FIG. 1A, the space 36 to the rear of the seat 71, 72 of each seat unit 40 is thus occupied by the first surface 47 of one seat and the second surface 48 of the other adjacent seat, said first and second surfaces 47, 48 of the one and other seat units 40 respectively being divided from one another by the privacy screen 60 of the one seat unit 40. The space 36 behind each seat 71, 72 is thus used to extend the length

of the bed surface 47, 48, 67, 74, 76 provided by the seat unit 40 in the bed configuration rearwardly of the seat 71, 72 into said space 36.

[0043] The acute angle at which the seat units 40 within a column 29 are oriented relative to the notional column axis B-B depends on the desired cabin layout. However, typically, the acute angle subtended by the notional seat axis C-C of each seat unit 40 and the column axis B-B is in the range of 30° to 60°, preferably 40° to 50°, for example about 40° as shown in FIG. 1. The seat units 40 may be oriented to face inwardly or outwardly with respect to the cabin 20, 21. In the first cabin 20 of FIG. 1, it can be seen that each of the outer columns 29 is disposed adjacent a respective one of the opposing side walls 26, 28, and the seat units 40 within each column 29 face inwardly. The second lateral edges 49 of the seat units 40 in each column 29 are substantially co-linear to form an elongate column outer edge which extends juxtaposed the side wall 26, 28 of the cabin 20. As a result of the curvature of the side walls 26, 28 in the first cabin 20, there is a small gap 27 between the outer column edge and each side wall 26, 28, and usually the gap 27 is filled using suitable infill panels of the kind well known to those skilled in the art.

[0044] In the second cabin 21, the seat units 40 of each outer column 29 also face inwardly and forwardly relative to the cabin 21. It will be seen from FIG. 1 that as the side walls 26, 28 of the second cabin 21 are substantially less curved than the side walls 26, 28 of the first cabin 20, the second edges 49 of the seat units 40 are disposed closer to the sidewalls 26, 28 than in the first cabin 20 and thus there are no or substantially no gaps between the outer column edges of the seat units and the opposing cabin side walls 26, 28. The seat units 40 of the two central columns 29 of the second cabin 21 also face forwardly, but are oriented to face outwardly with respect to the cabin 21. The two central columns 29 are arranged back-to-back such that the second linear edge 49 of each seat unit 40 in one central column 29 is disposed substantially contiguous a corresponding second linear edge 49 of another seat unit 40 in the other central column 29. As with the columns 29 of the first cabin 20, however, the seat units 40 of the columns 29 of the second cabin 21 are arranged such that to the rear of each seat 71, 72, the seat unit 40 defines a generally triangular or trapezoidal space 36 which is occupied by the first surface 47 of one seat unit 40 and the second surface 48 of another adjacent seat unit 40.

[0045] A privacy screen may be provided between the two central columns 29 said screen may comprise a movable portion member intermediate each pair of corresponding seats 40 in the two central columns 29, said position member being selectively movable automatically between a deployed position, in which said position member effectively forms a privacy shield between the two seats 40 of the pair, and a stowed and retracted position, in which the position member is removed, such that passengers using the two corresponding seats do

not have any boundaries between them in either the bed mode or the seat mode.

[0046] It has been found that the seating system in accordance with the present invention allows each seat unit 40, in the bed configuration, to provide a bed surface for a passenger having a length of at least 80 inches (2.032 metres) with a pitch between adjacent seat units 40 within each column 29 of 50 to 60 inches (1.27 to 1.52 metres). In some cases, it is possible to provide an overall bed length in the bed configuration in excess of 85 inches (2.16 metres) with such a pitch.

[0047] It will be appreciated that when the movable passenger-bearing elements 71, 72 of a seat unit 40 are disposed in a dining or lounge seat configuration as shown in FIG. 2, the space 36 to the rear of the seat 71, 72 is concealed by the upright or reclined back-rest 72. The space 36 thus provides a useful storage space which, in particular, can be used for storing bedding materials such as pillows, blankets, duvets and the like when the seat unit 40 is being used as a seat. Such bedding materials can be stored within the space 36 behind the seat 71, 72 such that the bedding materials are supported by the first surface 47 to the rear of the seat 71, 72. When a passenger wishes to go to sleep, the moveable passenger-bearing elements 71, 72, 76 can be selectively moved to the bed configuration as shown in FIG. 2, thus exposing the space 36 to the rear of the seat 71, 72 allowing easy access to bedding materials stowed therein. With the moveable seat elements 71, 72, 76 in the bed configuration, the extended bed surface provided by the seat unit 40 can be manually made-up with the bedding materials by a passenger or flight attendant to provide a fully made bed for the passenger.

[0048] In the seat configuration, a first passenger using the seat unit can sit on the seat formed by the seatpan 71 and back-rest 72, and a second passenger who might wish to visit the first passenger can sit on the auxiliary seat provided by the ottoman 65.

[0049] As shown in FIG. 1A, the second surface 48 of the seat unit 40 carries a hinged arm rest 75 which is hinged to the supporting structure 42 for swinging movement in the plane of the second surface 48 between a stowed position as shown in FIG. 1A in which the arm rest 75 extends substantially parallel to the second linear edge 49 and a deployed position (not shown) in which the arm rest 75 extends substantially parallel to the notional seat axis C-C between the front and rear ends of the cuboidal recess 44 juxtaposed the seat formed by the seatpan 71 and back-rest 72, so that a passenger using the seat may rest one of his or her arms on the arm rest 75. Alternatively, the arm rest 75 may be stored within a recess (not shown) formed in said surface 48 and means may be provided for translationally moving the arm-rest vertically between a stored position, in which said arm rest is accommodated within said recess, flush with said head surface 48, and a deployed position in which said arm-rest protrudes from the recess to provide an arm rest for an occupant of the seat.



This alternative has the advantage that in the stored position, the arm-rest does not impinge on the available surface area provided by the head surface 48. Another fixed arm rest (not shown) may be carried by the screen 60.

[0050] The seating system in accordance with the present invention thus comprises a plurality of self-contained seat units 40 which each provide individual seating and sleeping accommodation for a passenger. Within each column 29, it will be seen that the screen 60 to the second side 54 of one seat unit 40 and the screen 60 of another adjacent seat unit 40 disposed juxtaposed the first side 53 of the one seat unit 40 define a partially enclosed, private space for a passenger using the one seat unit 40.

[0051] Each seat unit 40 comprises a seat housing 43 and an ottoman 65, which ottoman 65 is spaced forwardly of the seat housing 43. However, the seat units 40 as described above may be conveniently manufactured by integrating the seat housing 43 of one seat unit 40 with the ottoman 65 of another adjacent seat unit 40. Thus, the supporting structure 42 forming the seat housing 43 of the one seat unit 40 may be integral with the supporting structure 42 forming the ottoman 65 of the other adjacent seat unit 40. Thus, the seating system in accordance with the present invention may be constituted by a plurality of seat modules 80 as shown in FIG. 1A, each module 80 comprising the seat housing 43 and moveable seat elements 71, 72, 76 of one seat unit 40 and the ottoman 65 of another adjacent seat unit 40. By attaching a plurality of said seat modules 80 to a pair of seat tracks 32, 34 in a cabin 20, 21, a plurality of seat units 40 can be assembled, each unit 40 comprising the seat housing 43 of one module and the ottoman 65 of another adjacent module 80.

[0052] Each seat module 80 is attached to a seat track pair 32, 34 at three points as shown in FIGS. 1 and 1A. In particular, each seat module 80 is attached to one seat track of the pair 32, 34 at two spaced points 38 and to the other seat track of the pair 32, 34 at a single point 39. Each seat module 80, may be attached directly to the seat track pair 32, 34 or, alternatively, the supporting structure 42 of each module 80 may comprise a plinth or palette (not shown), which plinth or palette is attached to the seat tracks 32, 34. In either case, the supporting structure 42 or plinth or palette is attached to the seat tracks 32, 34 using foot fixings of the kind well known to those skilled in the art. The use of a three-point fixing 38, 39 for attaching a seat module 80 to a seat track pair 32, 34 has been found to be advantageous over a conventional four-point fixing. In particular, it has been found that a three-point fixing allows a greater degree of flexibility between the two seat tracks of a pair 32, 34, thus allowing the two seat tracks to move or flex relative to one another in the event of an emergency landing or crash with a reduced risk of the seat modules 80 becoming detached from the seat tracks 32, 34.

[0053] The configuration of each seat unit 40, and the

arrangement of the seat units 40 within a cabin in accordance with the present invention, allows the occupant of each seat unit 40 easily to gain access to the seat unit 40 from the aisle and *vice versa*.

5 [0054] A first passenger seat assembly is shown in FIGS. 3 to 5. Said first passenger seat assembly can suitably be used to form a seat unit 40 of the seating system described above with reference to FIGS. 1, 1A, 2 and 2A. However, those skilled in the art will appreciate that the seating system in accordance with the present invention is not limited to the use of the seat assembly of FIGS. 3 to 5. Generally the seating system described above can comprise any seat unit 40 which defines a notional, longitudinal seat axis C-C and comprises a supporting structure 42 for supporting the seat unit off the floor 30 of a vehicle, means 71, 72 forming or being configurable for forming a seat comprising a seat-pan 71 and a back-rest 72 and means 47, 48, 67, 74, 76, forming or being configurable for forming a substantially flat bed, a major proportion of which bed is disposed forwardly of the position of the seat, which bed extends rearwardly behind the seat for extending the flat bed.

[0055] In FIGS. 3 to 5, parts of the first passenger seat assembly which correspond to parts of the seat unit 40 of FIGS. 1, 1A, 2 and 2A are indicated by the same reference numerals, with the addition of a preceding numeral "1".

[0056] The first passenger seat assembly 140 has a front end 151, a rear end 152 and two opposing sides 153, 154. The seat assembly 140 comprises a supporting structure 142 for fixedly securing the seat assembly 140 to seat tracks embedded in the floor 130 of a vehicle and for supporting the seat assembly 140 off the floor 130. Any suitable foot fixings of the kind known to those skilled in the art can be used for securing the supporting structure 142 to a pair of seat tracks. Whilst the first passenger seat assembly 140 of FIGS. 3 to 5 is particularly suitable for use on a passenger aircraft, it can also be suitably used on other forms of passenger vehicles such, for example, as trains, coaches and water-borne craft, including passenger ships and ferries and hovercraft.

[0057] Said supporting structure 142 comprises a seat housing 143 disposed generally towards the rear end 152 of the assembly 140 and an ottoman unit 165 disposed generally towards the front end 151 of the assembly 140. Said seat housing 143 defines a generally rectilinear or cuboidal recess 144 which is open at its upper end 201 and front end 202 and closed at its rear end 203 by a substantially vertically extending rear wall 204 and at each side by two spaced opposing, substantially vertically extending side walls 205, 206. In FIGS. 3 to 5, only one of the sidewalls 205 is visible. To the rear of the recess 144, the seat housing 143 defines a substantially flat first upper surface 147, and intermediate one side of the recess 144 and one side 153 of the assembly, the housing 143 further defines a substantial-

ly flat second upper surface 148 which is substantially coplanar, and may also be substantially continuous, with the first surface 147. Said first and second upper surfaces 147, 148 are sufficiently strong to support at least part of the weight of a passenger using the seat assembly 140.

[0058] Said ottoman unit 165 is spaced forwardly of the seat housing 143 and has a substantially flat upper surface 166 which carries a cushion 167 having a flat upper surface 169 which is substantially coplanar with the first and second upper surfaces 147, 148 of the seat housing 143. Said ottoman unit 165 is also sufficiently strong to support the weight of a passenger and can be used as an auxiliary seat.

[0059] Each of said side walls 205, 206 of the recess 144 carries a rotary bearing 222. Said rotary bearings 222 are aligned with one another to define a transverse axis which extends transversely across said recess 144 generally parallel to the floor surface 130, but at a slight incline thereto as described in more detail below. Said rotary bearings 222 are disposed at a height above the floor surface 130 approximately mid-way between the floor surface 130 and the first and second upper surfaces 147, 148. Said rotary bearings 222 are also positioned generally rearwardly within the recess 144 towards the rear wall 204. Each of said rotary bearings 222 receives a respective, laterally-extending trunnion 221 of a seat movement mechanism 220 as shown in FIGS. 6 to 8 in which the supporting structure 142 is omitted for clarity.

[0060] Each trunnion 221 is attached generally centrally to a substantially flat, outwardly-facing surface 226 of a respective, generally lenticular rocker plate 223. Each rocker plate 223 has a substantially linear first edge 224 and an opposing arcuate second edge 225. FIGS. 9 to 11 comprise detailed views of the rocker plates 223. Each rocker plate has an upper end 228 and lower end 229, and the two rocker plates 223 are fastened together by means of a generally cylindrical, transversely extending first torque tube 230 having two opposing ends 231, 232. Each end 231, 232 of the torque tube 230 is connected to an inner face 227 of a respective one of the rocker plates 223 juxtaposed the lower end 229. The first torque tube 230 thus serves to unite the two rocker plates 223 which define a recess 235 intermediate their respective opposing inner faces 227. The united rocker plates 223 are thus capable of rocking movement relative to the seat housing 143 about the trunnions 221 connected to the rotary bearings 222.

[0061] The arcuate edge 225 of each rocker plate 223 is pivotably connected towards its lower end 229 to one end 242 of a link 241 through a suitable pin joint. The other end 243 of the link 241 is pivotably connected to one end 244 of a rocker arm 245. As shown in FIGS. 14 and 15, the other end 246 of the rocker arm 245 is fixedly secured juxtaposed a respective end 251, 252 of a second rotatable torque tube 250. At one end 251, the sec-

ond torque tube 250 is rotatably supported within a hollow worm-gear casing 260. At the other end 252, the second torque tube 250 is rotatably mounted in a bearing 253 supported by the second side wall 206 of the recess 144.

[0062] Said worm-gear casing 260 has a substantially flat bottom surface 261 and defines a generally cylindrical interior cavity 262 which accommodates the bearing for the one end 251 of the second torque tube 250. Said one end 251 of the second torque tube 250 is fixedly secured coaxially to a worm-gear 271 which is accommodated within said cavity 262. The casing 260 has an upper wall 263 which is partially cut-away as shown at 264 to expose the teeth of the worm-gear 271. Said casing 260 is fixedly secured to the supporting structure 142 of the first seat assembly 140 within a recess (not shown) within the first side wall 205, beneath the second upper surface 148 at the rear of said recess 144, juxtaposed the rear wall 204.

[0063] The upper wall 263 of said casing 260 is formed with a generally upwardly extending lug 265, and a generally cylindrical worm-screw housing 273 is hinged to said lug 265 for movement between an engaged position as shown in FIG. 14 and disengaged position as shown in FIG. 15. Said worm-screw housing 273 is shaped such that in the engaged position, the housing 273 mates with the upper wall 263 of the worm-gear casing 260. As shown in FIG. 15, the worm-screw housing 273 is cut-away as shown at 274 to allow the teeth of the worm-gear 271 to extend into the interior of the worm-screw housing 273. As shown in FIG. 16, the worm-screw housing 273 accommodates a worm-screw 270 which is rotatably mounted between two opposing thrust-bearings 272. Said worm-screw 270 is rotatably coupled via a coaxial spindle 275 to an electric motor 280 having a motor housing 281 which is fixedly secured to the worm-screw housing 273. As shown in FIG. 16, the motor housing 281 is connected to the worm-gear casing 260 through two links 282, 283 which form a "break-link" device. One of said links 282 is pivoted to the motor housing 281 at one end 284 and to a first end of the other-link 283 at the other end 285. A second end 286 of said other link 283 is pivoted to the worm-gear casing 260. Said one link 282 is substantially larger than the other link 283 and, in the engaged position, the three pivot points 284, 285, 286 are co-linear such that the pivot point between the second end of the other link 283 and the worm gear casing 260 is disposed intermediate the pivot point 284 of the one link 282 to the motor housing 281 and the pivot point 285 between the two links 282, 285, such that the worm-screw housing 273 is prevented from disengaging the worm-gear casing 260. Said one link 282 can be selectively rotated clockwise as shown in FIG. 16, causing the other link 283 also to rotate clockwise, "breaking" the alignment of the three pivot points 284, 285, 286. The worm-screw 273 can then disengage from the worm-gear, allowing the rocker arms 245 to rotate freely about the axis defined by said

second torque tube 250, the links 282, 283 serving to limit the extent to which the worm-screw housing 273 can be disengaged from the worm-screw casing 260. Alternatively, instead of the break-link device, the worm-screw housing 273 could be releasably secured to the worm-gear casing 260 by means of a removable bolt, for example.

[0064] As shown in FIG. 9, the inner face 227 of each rocker plate 223 is fabricated with an elongate, substantially linear recess 301 which is substantially rectilinear in cross-section and extends substantially parallel to said first edge 224 from a lower end 302 juxtaposed the lower end 229 of the rocker plate 223 to an upper end 303 at a point intermediate said upper and lower ends 228, 229 of the plate 223. As shown in FIGS. 3 to 5, said elongate recess 301 accommodates a linear screw 304 having upper and lower ends 305, 306 as shown in FIG. 13. In some embodiments, ball screws or any other suitable, non-reversible linear actuator devices may be used instead of the two linear screws. At its upper end 305, each linear screw 304 is rotatably mounted in a bearing 307, which is fixedly secured to the rocker plate 223 at the upper end 303 of the recess 301. The lower end 306 of each linear screw 304 is accommodated within a gear casing 310 which is fixedly secured to the inner face 227 of the respective plate 223. (In FIG. 13, one of the gear casings 310 is omitted to reveal the detail at the lower end 306 of the linear screw 304). Said lower end 306 is supported by a rotary bearing 308 within the gear casing 310 and is rotatably coupled through a bevel gear 311 to a respective end 313, 314 of a rotary drive shaft 312. At one end 314, the drive shaft 312 is connected through a pair of interengaging pinions 315, 316 to a stepper motor 318 that is mounted to the gear casing 310 such that operation of the motor 318 causes rotation of the shaft 312 and thus rotation of the linear screws 304.

[0065] Each linear screw 304 carries a nut 320 comprising a shaped body 321. Said body 321 is generally T-shaped in cross section and comprises a substantially rectilinear slider portion 322 which is shaped to form a close, but free-sliding fit within the linear recess 301 formed in the inner face 227 of the respective rocker plate 223. Said slider portion 322 accommodates the linear screw 304 therein and comprises internal formations (not shown) for engaging the screw 304. Said body 321 further comprises a pair of opposing wing portions 324, each of which has a substantially flat outer face 325, the outer faces 325 of the two wing portions 324 being substantially co-planar to one another. The body 321 has a substantially flat inner face 326. With the slider portion 322 inserted in the linear recess 301 of the respective rocker plate 223, the outer faces 325 of the wing portions 324 lie closely adjacent the inner face 227 of the rocker plate 223.

[0066] With reference to FIG. 8, each of said nuts 320 is connected through a gimbal joint 329 to a respective lateral side edge 331, 332 of a structural diaphragm 330

forming part of a seat-pan element 171 which is disposed in the recess 235 intermediate the two opposing rocker plates 223. Said diaphragm 330 may comprise a light-weight, moulded composite panel or a perforated aluminium sheet. Said seat-pan element 171 has a rear end 333 and a forward end 334, said gimbal joints 329 being fitted to the diaphragm 330 towards said rear end 333 to allow the front end 334 of the seat-pan element 171 to be tilted upwards or downwards relative to the rear end 333 which moves less relative to the rocker plates 223. Said seat-pan element 171 includes suitable cushioning and upholstery which is supported by the diaphragm 330 to provide a comfortable seating surface for a passenger using the seat assembly 140. (The cushioning and upholstery is omitted in FIGS. 6 to 8 for clarity).

[0067] Juxtaposed the front end 334, the diaphragm 330 is pivotally connected to an upper end 341 of a depending lever 342. The other end 343 of the lever 342 is pivotally connected to a slider 345 which is slidably retained in an elongate, substantially linear slideway 350 that is fixedly secured to a respective one of the side walls 205, 206 of the seat housing 143 within said recess 144. As best seen in FIG. 3, each slideway 350 is oriented at an angle relative to the floor surface 130 such that the slideway 350 extends forwardly and upwardly within the recess 144 between an upper end 351 and a lower end 352. Said other end 343 of the lever 342 is also pivotally connected to a lower end 354 of a drag strut 355, said drag strut 355 having an upper end 356 that is pivotally connected to the first linear edge 224 of the respective rocker plate 223 juxtaposed the lower end 229 of the rocker plate 223.

[0068] With reference to FIG. 9, the inner face 227 of each rocker plate 223 is also formed with an elongate arcuate track 360 which extends juxtaposed the second arcuate edge 225 between an upper end 361 juxtaposed the upper end 228 of the plate 223 and a lower end 362 juxtaposed the lower end 229 of the plate 223. Intermediate the linear recess 301 and arcuate track 360, the inner face 227 of each plate 223 is also formed with a short linear slot 365 which extends from an upper end 366 juxtaposed the upper end 361 of the track 360 to a lower end 367 juxtaposed the upper end 303 of the linear recess 301. As best seen in FIG. 3, the linear slot 365 is angled with respect to the linear edge 224 of the plate 223 such that as the slot extends downwardly from the upper end 366 to the lower end 367, it extends inwardly of the plate from the linear edge 224 towards the arcuate track 260. It can also be seen that the arcuate track 360 and linear slot 365 diverge from one another from their respective upper ends 361, 366 towards their respective lower ends 362, 367.

[0069] The arcuate track 360 on each rocker plate 223 receives slidably two spaced friction blocks 371 that are fixedly secured to the outer surface 372 of a respective lower side member 373 of a lower back-rest element 374 as shown in FIGS. 6A and 6B. Said lower back-rest

element 374, together with an upper back-rest element described in more detail below, forms a back-rest component 172. Each lower side member 373 is generally L-shaped having an upper end 375, a lower end 376 and a substantially linear rear edge 377. At said lower end 376, each lower side member 373 comprises an enlarged foot portion 378 having a forwardly protruding nose 379. Each lower side member 373 has a substantially linear front edge 381 which extends between said upper end 375 and said enlarged foot portion 378 at a slight angle relative to the rear edge 377. As shown in FIGS. 6A and 6B, one of the friction blocks 371 on each lower side member 373 is mounted to said outer face 372 at the lower end 376 of the side member 373 at an angle of about 45° to the rear edge 377. Said other friction block 371 is mounted to said outer face 372 juxtaposed said rear edge 377 at a point intermediate said upper and lower ends 375, 376. The other friction block 371 also subtends an angle with the rear edge 377, but that angle is less than the angle subtended by the one friction block 371 and the rear edge 377.

**[0070]** Intermediate the two lower side members 373, the lower back-rest element 374 comprises a substantially flat diaphragm 385 which is spaced inwardly of both said front and rear edges 377, 381 to form rear and front lower recesses 386 and 387 respectively. Like the seat diaphragm 385 may comprise a moulded composite panel or a perforated metal sheet of the kind well-known in the manufacture of aircraft seats.

**[0071]** The outer face 372 of each side member 373 is further formed with a generally rectilinear, shaped cavity 390 having a peripheral side wall 391. Said cavity 390 is covered by a cover plate 380 (omitted in FIGS. 6A and 6B for clarity) which is fixedly secured to the outer face 372 of the side member 373. Said cavity 390 accommodates a generally triangular rocker lever 392 having an upper limb 393 and a lower limb 395. The rocker lever 392 is pivoted substantially centrally to the side member 373 at its obtuse apex 396.

**[0072]** The lower limb 395 is provided at its extremity with an outwardly directed pin 397, and the upper limb 393 is formed at its extremity with a lug 398. The rocker lever 392 is thus capable of rocking about said pivot 396 with corresponding rocking movement of the upper and lower limbs 393, 395. Movement of the rocker lever 392 is limited by the side wall 391 of the cavity 390 such that the upper limb 393 can rock between one position as shown in FIGS. 6A and 6B in which the lug 398 is disposed fully forwardly and another position (not shown) in which the upper arm 393 is disposed fully rearwardly.

**[0073]** The pin 397 on the lower limb 395 is slidably received in the linear slot 365 formed in the inner face 227 of the respective rocker plate 223. As best seen in FIG. 3, the lower back-rest element 374 extends upwardly of the rear end 333 of the seat-pan element 171 and is pivoted at its upper end 375 to said upper back-rest element 394. Said upper backrest element 394 comprises two spaced upper side members 402 and a

substantially flat upper diaphragm 403 which extends between said upper side members 402. Each of said upper side members 402 has a substantially linear rear edge 404 and a substantially linear front edge 405, and said upper diaphragm 403 is spaced inwardly of both said rear and front edges 404, 405 to define front and rear upper recesses 406 and 407 respectively. The lower and upper front recesses 387, 407 accommodate cushioning that is specifically designed to form a comfortable back-rest surface which, in conjunction with the cushioning on the seat-pan element 171, forms a dedicated seat surface for a passenger. The back-rest cushioning is upholstered to match the upholstering on the cushioning on the seat-pan element 171. The cushioning and upholstery of the upper and lower back-rest elements have been omitted in FIGS. 6, 6A, 6B, 7 and 8 for clarity. The upper and lower rear recesses 386, 406 define a substantially continuous recess which receives a substantially flat cushion or mattress suitable for forming a bed surface. Again this is omitted in FIGS. 6, 6A, 6B, 7 and 8 for clarity. In particular, however, the back-rest cushioning provided in the upper and lower front recesses 387, 407 may have a different style or colour of upholstery from the rear cushion or mattress. Furthermore, the cushioning provided on the front and rear surfaces respectively of the back-rest component may have different degrees of resilience as appropriate for seating and bedding purposes.

**[0074]** Each of said upper side members 402 has an upper end 409 and a lower end 411. Each upper side member 402 is pivotally connected to the upper end 375 of the respective lower side member 373 at 410 intermediate said upper and lower ends 409, 411, such that each upper side member 402 extends downwardly from the pivot point 410 to form a leg portion 412 having a generally U-shaped cut-out 414 at said lower end 411. Said U-shaped cut-out 414 slidably accommodates the lug 398 formed on the upper limb 393 of the respective rocker lever 392 for transmitting rocking movement of said arm 392 to the upper side member 402. Thus, rocking movement of the rocker lever 392 about its central pivot point 396 causes corresponding rocking movement of the upper back-rest element 394 about the pivot point 410 between the upper and lower back-rest elements.

**[0075]** With reference to FIG. 3, the nose 379 of each lower side member 373 is connected through a lost motion device 420 to one of the wing portions 325 on the nut 320 mounted on the linear screw 304 of the respective rocker plate 223. Each lost motion device 420 comprises a pin attached to the respective wing portion 325 at 328, which pin is received in a short slot formed in the nose 379 of the lower side member 373.

**[0076]** With reference to FIGS. 9 to 12, the arcuate edge 225 of each rocker plate 223 is formed towards the upper end 228 with a protruding lug 431 which is pivotally connected to one end 433 of an arm member 432 which arm member 432 terminates remote from the

lug 431 in another end 434. The two arm members 432 carry a transverse in-fill diaphragm member 440 which carries a generally rectilinear in-fill cushion 442 having an upper surface 443.

[0077] Juxtaposed the lug 431, the outer face 226 of each rocker arm 223 carries a small dog-leg member 450 which is pivoted to the rocker plate 223 at 451 between the lug 431 and the lower end 229 of the plate 223. Said dog-leg member 450 has a first limb 452 provided with a hook 453 at its extremity and a second limb 454 provided with a cam follower 455. Each arm member 432 has an outwardly extending holding pin 456, and the outer surface 226 of each rocker plate 223 is formed with an outwardly extending stop pin 457 which is positioned between the pivot point 451 and the arcuate edge 225 of the plate 223. The dog-leg member 450 is freely rotatable about the pivot 451, and the stop pin 457 serves to limit clockwise rotation of the dog-leg member 450 of the plate 223 as shown in FIGS. 9 to 12. (The stop pin on the other rocker plate 223 limits counter-clockwise movement of the corresponding dog-leg member 450).

[0078] The cam follower 455 on the second limb 454 of the dog-leg member 450 engages a cam 460 (see FIGS. 8 and 12) formed on the respective sidewall 205, 206 of the recess 144 for controlling movement of the dog-leg member 450.

[0079] As shown in FIG. 3, the first seat assembly 140 as hereinbefore described can be arranged in a upright seat configuration in which the rocker arms 245 extend forwardly relative to the rotary shaft 50 within the recess 144 and the links 241 are substantially co-linear with the rocker arms 245 such that the united rocker plates 223 are oriented in a seat configuration as shown in FIGS. 3, 4, 6, 7, and 10 in which the linear edge 224 of each rocker plate 223 extends upwardly and rearwardly within the recess 144, with the arcuate tracks 360 on the two rocker plates 223 extending generally downwardly and forwardly within the recess 144. As the links 241 and rocker arms subtend an angle of 180° to form a compression strut in the seat position, any loads applied to the rocker plates 223 are applied linearly to the second torque tube 250 and no rotational force is applied to the worm-gear 271. Advantageously, the seat conversion sub-mechanism of the seat assembly is capable of withstanding large forward forces, without the need for any additional disengageable mechanical coupling, such as a shoot-bolt, between the seat movement mechanism and the supporting structure. In the upright seating configuration, the nuts 320 are disposed at the upper ends 305 of their respective linear screws 304 as shown in FIG. 13, and the lower ends 343 of the levers 342 are disposed at the upper ends of the slideways 350 such that the seat-pan element 171 is disposed substantially horizontally within the recess 144, with the upper surface of the seat-pan cushioning at approximately the same level as the first and second upper surfaces 147, 148 on the seat housing 142 and the upper surface 169

of the cushion 167 on the ottoman 165. The friction blocks 371 on the lower side members 373 of the lower back-rest element 374 are disposed at the upper ends 361 of the arcuate tracks 360 on the rocker plates 223, and the pins 397 on the rocker levers 392 are disposed at the upper ends 366 of the linear slots 365 on the rocker plates 223. Accordingly, the upper limbs 393 of the rocker levers 392 are disposed fully forwardly within their respective cavities 390, such that the upper back-rest element 394 is substantially co-linear with the lower back element 373.

[0080] In the upright position of FIG. 3, the dog-leg members 450 on the rocker plates 223 are disengaged from the respective cam members 460, and the arm members 432 are disposed, as shown in FIG. 10, in a stowed position with the in-fill cushion 442 disposed generally beneath the first upper surface 147 of the seat housing 143. In the upright position, the cushioning 408 on the upper and lower back-rest elements 373, 394 forms an ergonomically comfortable seat with the cushioning on the seat-pan element 171.

[0081] In the upright position, the seat defined by the seat-pan element 171 and back-rest element 172 is generally suitable for dining. The ottoman unit 165 is spaced forwardly of the seat-pan element 171 and may be used as a foot-rest for the passenger.

[0082] From the upright position of FIG. 3, the seat assembly may be reclined to a fully reclined position as shown in FIG. 4 as follows. Upon operation of the stepper motor 318, the linear screws 304 on the rocker plates 223 are caused to rotate. As the nuts 320 are restrained from rotation with the linear screws 304, the nuts are driven translationally along the linear screws 304 towards the lower ends 302 of the recesses 301 formed in the opposing inner faces 227 of the rocker plates 223. As the nuts 320 are driven downwardly, the rear end 333 of the seat-pan element 171 is also driven downwardly relative to the front end 334 which is supported by the levers 342. The rear end 333 of the seat-pan element 171 is thus driven downwardly causing the seat-pan element to tilt rearwardly about the pivot between the upper ends 341 of the levers 342 and the front end 334 of the seat-pan diaphragm 330. As the linear screws 304 extend downwardly and forwardly within the recess 144, the seat-pan element 171 is also driven forwardly, which forwards movement is accommodated by forward rocking of the levers 342 about the pivots between the lower ends 343 of the levers 342 and the sliders 354 in the respective slideways 350.

[0083] The front end 334 of the seat-pan element 171 therefore moves downwardly slightly in the recess 144, but not to the same extent as the rear end 333 of the seat-pan element 171. Movement of the sliders 354 rearwardly along the slideway 350 is prevented by the drags struts 355 between the sliders 354 and the rocker plates 223.

[0084] Forwards and downwards movement of the nuts 320 also causes corresponding movement of the

back-rest element 172 which is connected to the nuts 320 through the lost motion devices 420 on the noses 379 of the lower back-rest elements 373. Movement of the back-rest component 172 causes the friction blocks 371 to slide in their respective arcuate tracks 360 on the opposing inner faces 227 of the rocker plates 223 from the upper ends 361 of the tracks 360 towards the lower ends 362. The relative orientation of the friction blocks 371 as described above and the curvature of the tracks 360 have the result that, as the friction blocks 371 slide along the tracks 360, the lower back-rest element 373 is caused to rock rearwardly as shown in FIG. 4 from the upright position of FIG. 3 to a fully reclined position as shown in FIG. 4.

[0085] Contemporaneously, the pins 397 on the rocker levers 392 are caused to slide along the linear slots 365 on the rocker plates 223. As each linear slot 365 diverges from the corresponding arcuate track 360 on the same rocker plate 223, the upper limb of each rocker lever 392 is caused to rock rearwardly in the respective cavity 390. Rearwards movement of the upper limbs 393 of the rocker levers 392 causes the upper side members 402 of the upper back-rest element 394 to rock forwardly relative to the lower back-rest element 373. As the back-rest component 172 is driven forwardly and downwardly by movement of the nuts 320, the upper back-rest element 394 rocks progressively further forwards relative to the lower back-rest element 373 until the rocker levers 392 engage the side walls 391 of the respective cavities 390, preventing further forwards rocking of the upper back-rest element 394. The relative positions and profiles of the recesses 301, tracks 360 and slots 365 formed on the two rocker plates 223 are carefully calculated to ensure that as the seat reclines from the upright position of FIG. 3 towards the fully reclined position of FIG. 4, the seat-pan element 171 and upper and lower back-rest elements 374, 394 move through a plurality of predetermined, ergonomically comfortable positions.

[0086] The stepper motor 318 can be controlled such that the nuts 320 can be stopped at any intermediate position between the upper and lower ends 305, 306 of the linear screws 304. Thus, movement of the seat defined by the seat-pan element 171 and upper and lower back-rest elements 374, 394 can be halted in any intermediate position between the upright position of FIG. 3 and fully reclined position of FIG. 4. The angle subtended by the upper and lower back-rest elements 374, 394 in a reclined position has the effect that the lower back-rest element 374 advantageously provides lumbar support for a passenger using the seat assembly 140.

[0087] The linear screws 304 are non-reversible linear actuator devices, and thus the seat assembly of the present invention has the added advantage that forces applied to the seat-pan element 171 or back-rest component 172 cannot be transmitted through the nuts 320 and linear screws 304 to the motor 318. This has the advantage that sudden and/or strong forces applied to the moveable seat elements 171, 374, 394 are not

"seen" by the stepper motor, thus reducing the risk of damage to the stepper motor 318.

[0088] A particular feature of the first seat assembly 140 as hereinbefore described is that it can be converted from the upright position of FIG. 3 to a bed configuration as shown in FIG. 5. In order to convert the seat assembly 140 from the upright configuration to the bed configuration, the motor 280 is operated to cause rotation of the worm-screw 270. With the worm-screw housing 273 in the engaged position on the worm-gear casing 260, rotation of the worm-screw 270 causes corresponding rotation of the worm-gear 271 and thus rotation of the second torque tube 250. Rotation of the torque tube 250 in turn causes rotation of the rocker arms 245 from a seat position as shown in FIG. 15 to a bed position as shown in FIG. 14.

[0089] With reference to FIGS. 3 and 5, rotation of the rocker arms 245 rearwardly causes the links 241 to rock the rocker plates 223 forwardly about the trunnions 221. Rocking of the rocker plates 223 forwardly within the recess 144 causes the lower back-rest member 374 to rock forwardly about the trunnions 221. The gimbal joints 329 between the seat-pan element 171 and the nuts 320 also rotate about the trunnions 222, and rocking of the rocker plates 223 causes the drag struts 355 to pull the sliders 354 at the lower ends 343 of the levers 342 rearwardly and downwardly along the slideways 350 from the upper ends 351 of the slideways towards the lower ends 352. The front and rear ends 334, 333, of the seat-pan element 171 are thus caused to descend within the recess 144, such that the back-rest component 172 rocks forwardly over the seat-pan element 171 as shown in FIG. 5.

[0090] In the bed configuration of FIG 5, the seat-pan element 171 is disposed in a lower stowed position within the recess 144, and the cushioning or mattress in the lower and upper rear recesses 386, 406 of the back-rest component 172, is disposed substantially coplanarly with the upper surfaces 147, 148 of the seat housing 143 and of the cushioning 167 on the ottoman unit 165. It can also be seen from FIG. 5 that the upper and lower back-rest elements 374, 394 are dimensioned such that in the bed configuration, the upper ends 409 of the upper side members 402 meet the ottoman unit 165 such that the cushioning or mattress on the rear surface of the backrest component 172 forms a substantially continuous surface with the cushion 167 on the ottoman unit 165 and with the second upper surface 148 on the seat housing 143. Advantageously, the upper end 409 of the upper back-rest element 394 may engage a formation (not shown) on the ottoman unit 165, such that in the bed configuration part of the load applied to the back-rest component 172 is borne in part by the ottoman unit. The engagement of the rocker levers 392 with the side walls 391 of their respective cavities on the lower side members 374 of the lower back-rest element 373 serves to lock the upper and lower back-rest elements 373, 394 together to prevent buckling of the back-rest component

172 under load in the bed configuration.

[0091] Movement of the rocker plates 223 from the seat position to the bed position also raises the arm members 432 carrying the in-fill cushioning 443 within the recess 144. In the seat position as shown in FIG. 10, the dog-leg members 450 are disengaged from the cams 460 formed on the side surfaces 205, 206 of the recess 144 and can pivot freely about the pivot points 451. As mentioned above, however, movement of the dog-leg members 450 is limited by the stop pins 457.

[0092] As the rocker plates 223 are rocked forwardly towards the bed configuration of FIG. 5, the holding pins 456 on the arms 432 become trapped behind the hooks 453 on the first limbs 452 of the dog-leg members 450. As the rocker plates 223 move towards the bed configuration, the cam followers 455 engage the cams 460, thus locking the dog-leg members 450 in place, trapping the holding pins 456 behind the hooks 453.

[0093] As best seen in FIG. 5, the arm members 432, cushioning members 442, holding pins 456, dog-leg members 450 and cams 460 are shaped and positioned such that, in the bed configuration, the upper surface 443 of the in-fill cushioning member 442 fills a space between the lower end 376 of the lower back-rest element 374 and the forward end of the first upper surface 147 of the seat housing 143. The upper surface 443 of the in-fill cushioning member 442 is disposed substantially continuously and substantially coplanarly with the cushioning or mattress on the rear of the back-rest component 172 and the first upper surface 147 to form an extended, substantially flat bed surface.

[0094] The supporting structure 142 of the seat assembly 140 is configured such that, in flight, with the floor surface 130 at an angle of about 1-3° to the horizontal, the bed surface provided by the seat assembly of the present invention is disposed substantially horizontally relative to Earth. In other words, the seat assembly 140 of the present invention compensates for the slight incline of the aircraft in flight.

[0095] Advantageously, the worm-gear, worm-screw assembly 271, 270 is non-reversible, and so in the bed and seat configurations, the motor 280 does not "see" undue forces applied to the rocker plates 223. In other words, undue or sudden forces applied to the rocker plates 223 are not transmitted through the worm-gear/worm-screw assembly to the motor 280.

[0096] The first passenger seat assembly 140 as hereinbefore described is equipped with user-operable controls mounted conveniently to the supporting structure 142. Said controls comprise means for operating the stepper motor 318, for selectively moving the seat-pan and back-rest moveable elements 171, 374, 394 between the upright position of FIG. 3 and the fully reclined position of FIG. 4, and for operation of the motor 280 for converting the moveable elements 171, 374, 394 between the upright seat configuration of FIG. 3 and the bed configuration of FIG. 5 in which the moveable back-rest elements 374, 394 cooperate with the fixed auxiliary

elements of the supporting structure 142, i.e., the ottoman unit 165 and first and second upper surfaces 147, 148 of the seat housing 143 to form an extended, substantially flat bed for the passenger. Said controls comprise control circuitry for ensuring that if a passenger attempts to convert the seat assembly 140 from the seat configuration to the bed configuration when the seat is in a reclined or fully reclined position, the stepper motor 318 is first operated to return the moveable seat elements 171, 374, 394 to the fully upright position before the motor 280 is operated to convert the seat into the bed configuration. In the event of a failure of the motor 280 or of the aircraft cabin power supply, the seat assembly 140 can be returned to the upright position of FIG. 3 by breaking the break-link device 282, 283 as described above and manually rocking the rocker arms 245 forwardly to the seat position of FIG. 15.

[0097] The first passenger seat assembly 140 as hereinbefore described thus provides self-contained, individual seating and sleeping accommodation for a passenger.

[0098] FIG. 17 shows another seating system in accordance with the present invention comprising a plurality of first passenger seat assemblies 140 of the kind hereinbefore described with reference to FIGS. 3 to 16. In FIG. 17, an aircraft fuselage 510 encloses a passenger accommodation cabin 520 at a position rearwardly of a nose portion 515 of the fuselage 510. As in the case of the seating system of FIG. 1, the accommodation cabin 520 of FIG. 17 is defined by two opposing interior surface portions 526, 528 of the fuselage 510, a floor surface or deck 530 supported within the fuselage 510 on suitable supporting infrastructure (not shown) and a ceiling (also not shown). The infrastructure includes a plurality of pairs of seat tracks 532, 534 which are embedded in the floor surface 530. The cabin 520 of FIG. 17 includes two outer pairs of seat tracks 532, each extending juxtaposed a respective one of the opposing surface portions 526, 528 of the fuselage 510 and a single, central seat track pair 534. Each of the seat track pairs 532, 534 extends substantially parallel to a longitudinal aircraft axis defined by the fuselage 510 and indicated in FIG. 17 by the chain dot line A-A.

[0099] The seat assemblies 140 are attached to the seat tracks 532, 534 to form a plurality of columns 529. Each column 529 is fixedly secured to a respective one of the seat track pairs 532, 534 and defines a notional, longitudinal column axis indicated by lines B-B in FIG. 17. Each seat assembly 140 defines a notional, longitudinal seat axis, indicated by lines C-C in FIG. 17, which subtends an angle of about 49° to the notional column axis B-B. The seat assemblies 140 attached to the outer seat track pairs 532 face forwardly and inwardly within the cabin 520. The seat assemblies 140 attached to the central pair of seat tracks 534 form two groups 537, 538. A forward group 537 of seat assemblies 140 attached to the centre seat track pair 534 face forwardly and to one side of the cabin 520, whilst a rear group 538 face

forwardly and to the other side of the cabin 520.

[0100] As in FIG. 1, within each column 529, the seat assemblies of FIG. 17 are arranged side-by-side in a longitudinal off-set relation to one another so as to define a generally triangular or trapezoidal space 536 to the rear of each seat assembly 140, behind the backrest component 172 when the seat assembly 140 is in the seat configuration. As described above, each seat assembly 140 is self-contained, capable of providing an individual, extended flat bed having a length of at least 80" (2.02 metres) for a passenger, and the arrangement of seat assemblies 140 in accordance the seating system of FIG. 17 allows the seat assemblies 140 to be accommodated within the cabin 520 at a pitch of about 50 to 60" (1.27 - 1.52 metres). Thus, a plurality of seat assemblies 140, each providing an individual bed of at least 80" (2.032 metres) length, can be accommodated within a typical business class cabin of a passenger aircraft.

[0101] The interior surface of an aircraft fuselage 510 is concave in vertical cross-section, and thus within the cabin 520 of FIG. 17, each of the opposing interior surface portions 526, 528 of the fuselage 510 defines a lateral recess at each side of the cabin 520. Advantageously, this lateral recess is occupied by the first and second passenger-supporting auxiliary surfaces 147, 148 of each seat assembly 140 attached to one of the outer seat track pairs 532. The first and second supporting surfaces 147, 148 form part of the extended flat bed surface provided by each seat assembly 140 in the bed configuration and, whilst the lateral recess has insufficient head room to accommodate the full height of the seat in an upright or reclined seating configuration, its use to accommodate part of the extended bed surface for which the headroom requirement is less represents an efficient use of the space available within the cabin.

[0102] In accordance with the present invention, the upholstery used to dress the seat-pan element 171 and cushioning 408 provided on the back-rest elements 374, 394 of each seat assembly 140 may be selected such that when all or a majority of the seat assemblies 140 of the seating system of FIG. 17 are arranged in a seating configuration, the cabin has a first particular appearance and/or ambience which is suitable for dining and/or lounging. The bedding materials provided for dressing the cushions provided in the lower and upper rear recesses 386, 406 on the back-rest component 172 may have patterns and/or colourways which are particularly appropriate for a sleeping environment. In particular, the style of the bedding materials may be selected such that when all or a majority of the seat assemblies 140 of the seating system of FIG. 17 are in the bed configuration, the cabin 520 may have a different second appearance or ambience which is more "restful" than the first appearance and is more appropriate for a sleeping environment.

[0103] Another passenger accommodation unit is illustrated in FIGS. 18-23. As shown in FIG. 18, the other

passenger accommodation unit comprises a shell 710 which is formed from two half shells 710a and 710b. Said shell 710 comprises a rear screen 712 and a front screen 714 that are interconnected by an interconnecting side wall 716. Behind the rear screen 712, the shell comprises a hollow foot-box 730 having opposing side walls 732 and a top wall 736 which includes a substantially flat, horizontal portion 738 that serves as a drinks side-table for a neighbouring seat.

[0104] The shell 710 of FIGS. 18-23 is mounted on a plinth 760. Said plinth 760 is manufactured from a suitable aircraft grade, light-weight, structural material, typically the same material as the shell 710, and has a planar bottom wall 762 which is fitted with suitable fixings (not shown) for fixing the plinth substantially to the seat tracks.

[0105] Said plinth 760 is formed with a recess 764 which is defined by an upstanding side wall 763 having an inwardly directed, upper rim 765. Said recess 764 extends from the front screen 714 under the entire seat into the foot-box 730 which is positioned at floor level. The recess 764 accommodates a mattress or similar cushioning or padding suitable for forming a bed for a passenger. Said recess is shaped to compensate for the slight incline of the aircraft in flight such that said mattress is substantially horizontal. Juxtaposed the front screen 714, the shell 710 carries a movable pedestal 740 which is movable on a substantially vertical axis between a lower deployed position as shown in FIGS. 18 and 20A and a raised, stowed position as shown in FIG. 20B. Whilst various mechanisms for achieving such movement of the pedestal will be apparent to those skilled in the art, an example of a suitable mechanism would be inter-engaging runners fitted on the inner surface of the front screen 714 and on the pedestal 740. Suitable means are provided for locking the pedestal 740 in the upper and lower positions.

[0106] Said shell 710 defines a personal passenger space 718 which accommodates a seat 720 comprising a seat-pan 722 and a backrest 724. Said backrest 724 is permanently fixed to the inner surface of the rear screen 712, whilst the seat-pan is pivoted at its rear edge 723 to the inner surface of the rear screen 712 for movement between a deployed position as shown in FIGS. 18 and 20A and a stowed position as shown in FIGS. 19 and 20B. In the deployed position the front edge 725 of the seat-pan 722 is supported by inwardly directed protrusions 752 formed on the shell 710 which constitutes supporting structure for the seat assembly 720.

[0107] Beneath the seat-pan 722, the rear screen 712 of the shell 710 is formed with an aperture 729 to allow access from the passenger space 718 into the interior of the foot-box 730. Said mattress extends beneath the seat assembly 720 through the aperture 729 into the foot-box 730.

[0108] Intermediate the seat-pan 722 and pedestal 740, the recess 764 is covered by a removable false



floor panel 770 which is made from a suitable aviation standard, load-bearing material. Said false floor panel 770 is preferably connected to said interconnecting side wall 716 for movement between a deployed position as shown in FIG. 22 and a stowed position in which the panel 770 extends substantially vertically and lies contiguous the side wall 716. Securing means are provided for securing the panel in the stowed position.

[0109] Juxtaposed the seat-pan of a neighbouring unit, the first side wall 732' of the foot-box is formed with an external recess 733' which is provided with an upholstered shelf 735' at the same level as the seat-pan 722 of the neighbouring unit to provide a lateral extension of said seat-pan 722.

[0110] The accommodation unit 720 can thus be selectively manipulated between a "seat mode" as shown in FIGS. 18 and 20A in which the seat-pan 722 is deployed and a "bed mode" as shown in FIGS. 19 and 20B in which the seat-pan 722 is pivoted upwardly about its rear edge 723 to lie flat against the inner surface of the backrest 724 in the stowed position. In the bed mode, the removable false floor panel 770 can be moved to the stowed position, and the pedestal 740 raised from its lower position to its raised position thereby to expose the mattress within the recess 764 of the pedestal 760. Raising the seat-pan 722 to its stowed position facilitates access to the foot-box 730 and provides a more spacious personal space 718 within the shell 710 in the bed mode.

[0111] Thus, in the seat mode as shown in FIG. 20A, a passenger may sit on the seat provided by the unit 720 and, if desired, may rest his or her feet on the pedestal 740 in its lower position. If the passenger desires to go to bed, then he or she may stand up and lift the seat-pan 722 to its stowed position as shown in FIG. 20B. The pedestal 740 may be raised to its elevated position and the false floor panel 770 may be removed. The passenger may then lie down on the mattress within the recess 764 with his or her head towards the front panel 714 and his or her lower legs extending into the foot-box 730. By orienting the unit at an angle of about 40-50 degrees, for example about 45 degrees to the direction of travel of the vehicle, an overall bed length of up to about 7ft (2.13 metres) may be provided. The front screen 714 serves to protect the passengers' head whilst asleep, and the pedestal 760 provides a step-up into the passenger's personal space which many passengers find attractive. The shell above the foot-box may be shaped to provide a lateral seat extension 735 for the seat-pan 722 of a neighbouring seat and a generously proportioned occasional side-table 738 for use by the neighbouring seat.

[0112] In a variant of the other accommodation unit of FIGS. 18-20, the seat-pan 722, instead of pivoting about its rear edge 723 to lie flat, in its stowed position, against the front surface of the backrest 724 may be arranged to slide relative to the shell 710 between a forward position as shown schematically in FIG. 22A and a retract-

ed position as shown in FIGS. 21 and 22C. In the retracted position, the seat-pan 722, or at least a major proportion of the seat-pan 722 may be accommodated within the foot-box 730 at a position vertically spaced above the mattress. Various mechanisms suitable for achieving such sliding movement of the seat-pan 722 will be self-evident for those skilled in the art, for example linear bearings provided on the interior surfaces of the shell 710 adjacent to the seat-pan 722. Advantageously, the sliding mechanism may be provided with one or more detents (not shown) for selectively halting movement of the seat-pan 722 in at least one intermediate position such as that shown in FIG. 22B. Thus, in the fully extended position, as shown in FIG. 22A, the unit may be configured ergonomically for relaxing, whilst in the intermediate position as shown in FIG. 22B, the unit may be configured to provide a more upright passenger position which is suitable, for example, for dining or working. In the fully retracted position, the seat-pan 722 is substantially stowed to allow access to the foot-box 730 when the seat is in bed mode.

[0113] Another variant is shown in FIG. 23 in which the removable false floor panel 770 is hinged to the interconnecting side wall 716 for movement between a deployed position in which it lies generally horizontally over the recess 764 to protect the mattress and a stowed position as shown in FIG. 23 in which it lies flat in a substantially vertical orientation against the interconnecting side wall 716. The underside 772 of the false floor panel 770 may be upholstered with suitable cushioning, such that together with the mattress 764, it provides a sofa-like arrangement; a passenger may sit sideways on the mattress 764 in the bed mode with his or her back-resting against the underside 772 of the panel 770.

[0114] Yet another seating system in accordance with the present invention is illustrated in FIG. 24. The particular system of FIG. 24 is designed specifically for use on the upper and lower decks of a Boeing 747-400 @ aircraft, but the system may be adapted for use on any passenger aircraft, particularly in a business class cabin. The seating system of FIG. 24, on each of the upper and lower decks, comprises a plurality of passenger accommodation units 800, for example the accommodation units of FIGS. 18-23. Each of said units 800 is positioned juxtaposed a cabin side wall 810 and is oriented at an angle of about 40-50 degrees, preferably about 45 degrees, to the longitudinal direction of the juxtaposed side wall 810, with the rear of the unit towards the wall 810, such that the seat faces generally inwardly of the cabin. By orienting units 800 to face inwardly, the cabin is given a less crowded appearance as compared with a cabin in which seats are aligned substantially fore-and-aft. Each unit has a generally triangular or trapezoidal extension box or space 830 between the rear of the unit and the juxtaposed cabin side wall 810. Generally, the walls of an aircraft cabin are concave on the interior, and accordingly the extension box or space 830 of each unit 800 extends into the concave recess defined by the

wall to optimise the use of space in the cabin. Each unit 800 comprises means adapted to provide a bed as described above which extends into the extension box or space to maximise the available bed length.

[0115] In some aircraft floor plans, there may also be sufficient space to dispose one or more units towards the centre of the cabin, as shown for the lower deck of the Boeing 747-400 @ in FIG. 24. In that embodiment, two central lines of units are provided in which each unit is oriented at an angle of about 45 degrees to the direction of travel of the aircraft. The central units 800 are arranged in pairs, with each seat facing generally forwardly and outwardly of the cabin, such that the two units of each pair diverge from one another in the forwards direction and define a generally quadrilateral space behind the units in front of the pair of units behind. Said quadrilateral space 840 accommodates an extension box or space associated with each unit 800 in order to provide an extended bed length for each unit. Where each unit 800 comprises a hollow foot-box of the kind described above with reference FIGS. 18-23, the top wall of each foot-box may be adapted to provide a convenient side-table or other furniture means for another unit.

#### Claims

1. A seating system for a passenger vehicle, particularly an aircraft, comprising a plurality of seat units, each seat unit defining a notional longitudinal seat axis and comprising a supporting structure adapted for attaching the seat unit to a floor of a vehicle and means forming or being configurable for forming a seat comprising a seat-pan and a back-rest, said seat units being arranged to form a column defining a notional longitudinal column axis, in which column said seat-units are arranged side-by-side in longitudinally offset relation at an acute angle to a notional column axis, thereby defining a space to the rear of each seat, each seat unit further comprising means forming or being configurable for forming a substantially flat bed, a major proportion of which bed is disposed forwardly of the position of the seat, which bed extends rearwardly into said space to extend the flat-bed.
2. A seating system as claimed in claim 1, **characterised in that** each seat unit includes a passenger supporting element in said space to the rear of the seat, which passenger supporting element forms part of said flat bed.
3. A seating system as claimed in claim 1 or claim 2, **characterised in that** said acute angle is in the range 30 - 60°, preferably 40 - 50°, e.g. 45°.
4. A seating system as claimed in claim 1, claim 2 or claim 3, wherein said vehicle comprises an accommodation cabin, which cabin defines a notional longitudinal cabin axis, and wherein said notional column axis is substantially parallel to or subtends an acute angle with said cabin axis.
5. A seating system as claimed in any preceding claim, **characterised in that** said seat units are disposed adjacent a side wall of the vehicle and face inwardly, or are disposed back-to-back with the seat units in another column.
6. A seating system as claimed in any preceding claim, **characterised in that** each seat unit further comprises a foot-rest that is positioned forwardly of the seat.
7. A seating system as claimed in claim 6, wherein each seat unit further comprises a first privacy screen that is positioned forwardly of said foot-rest.
8. A seating system as claimed in any preceding claim, **characterised in that** said seat forming means and said bed forming means comprise one or more movable passenger-bearing elements which are selectively configurable to form, in a seat mode, at least part of the seat for a passenger or, in a bed mode, at least part of said flat bed, and wherein the flat bed in the bed mode is disposed at substantially the same level as the seat-pan in the seat mode.
9. A seating system as claimed in claim 8, wherein each seat unit comprises a first passenger-supporting element in said space to the rear of the seat, which first passenger-supporting element is disposed substantially coplanarly with said one or more movable elements when said movable elements are configured in the bed mode and is adapted to form part of said flat bed.
10. A seating system as claimed in claim 9, wherein each seat unit further comprises a second passenger-supporting element to one side of each seat, which second passenger-supporting element is disposed substantially coplanarly with said first passenger supporting element and is adapted to form part of said flat bed when the movable elements are configured in said bed mode, thereby to extend said flat bed laterally.
11. A seating system as claimed in claim 10, wherein the first fixed element of one seat unit is disposed substantially contiguously to the second fixed element of an adjacent seat unit, said first and second elements being divided from one another by a second privacy screen.

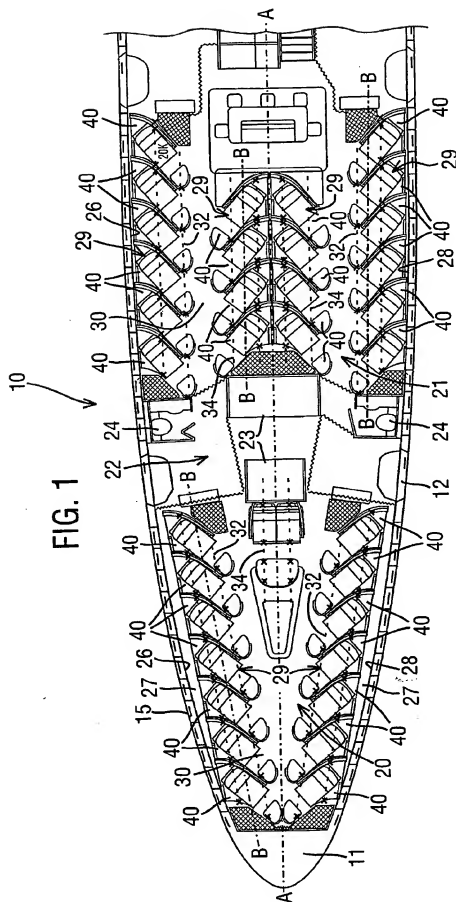
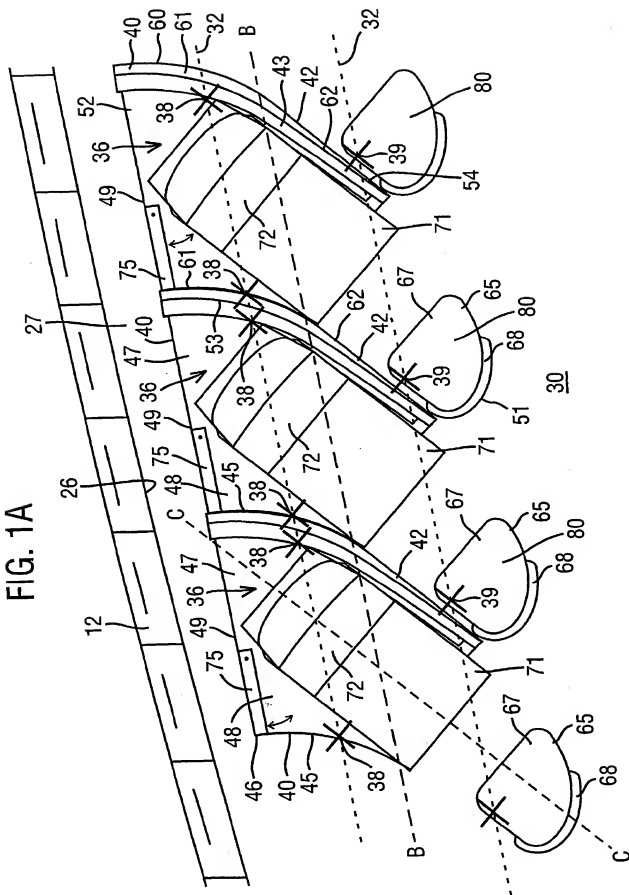


FIG. 1A



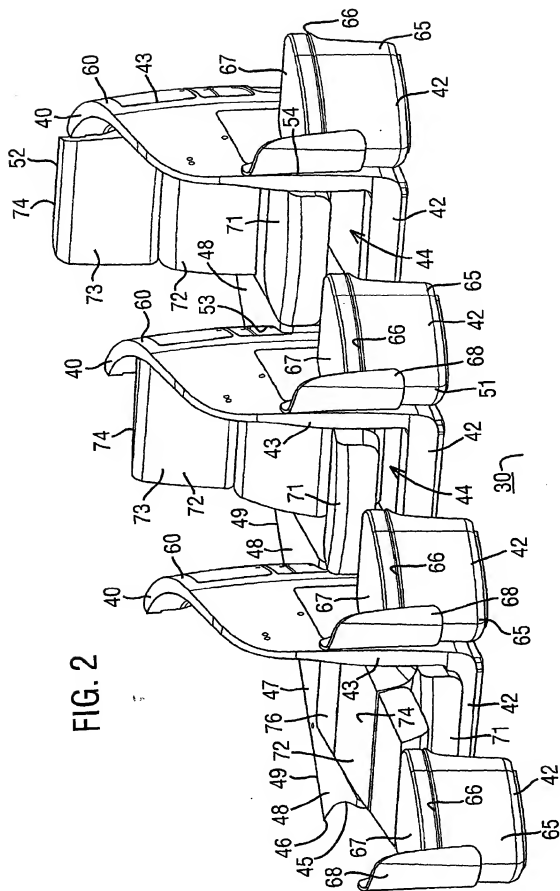


FIG. 2A

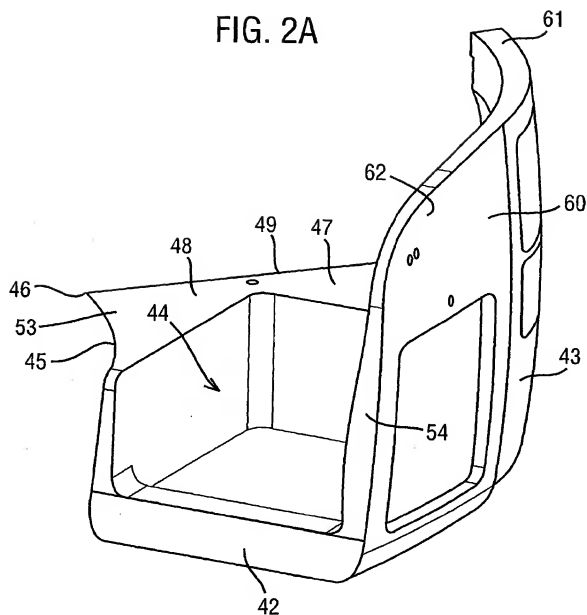


FIG. 3

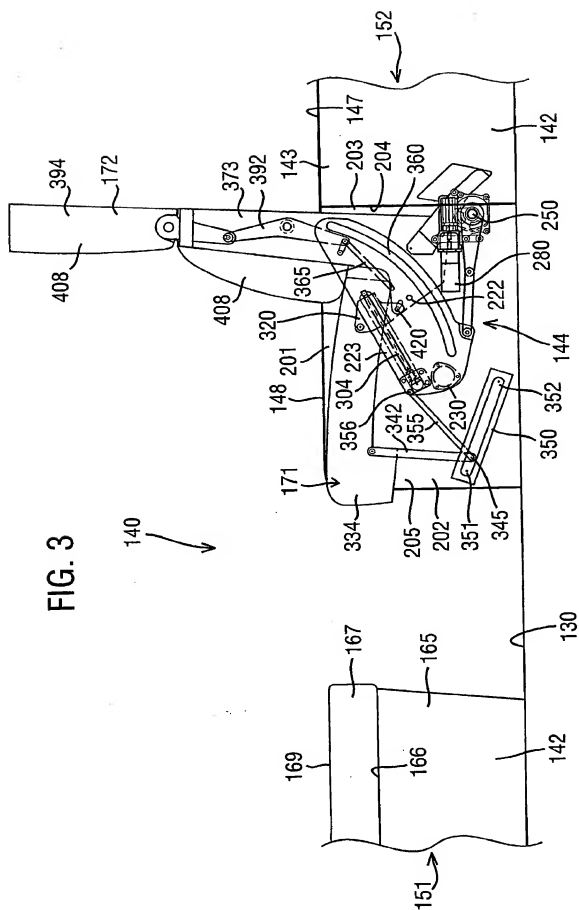
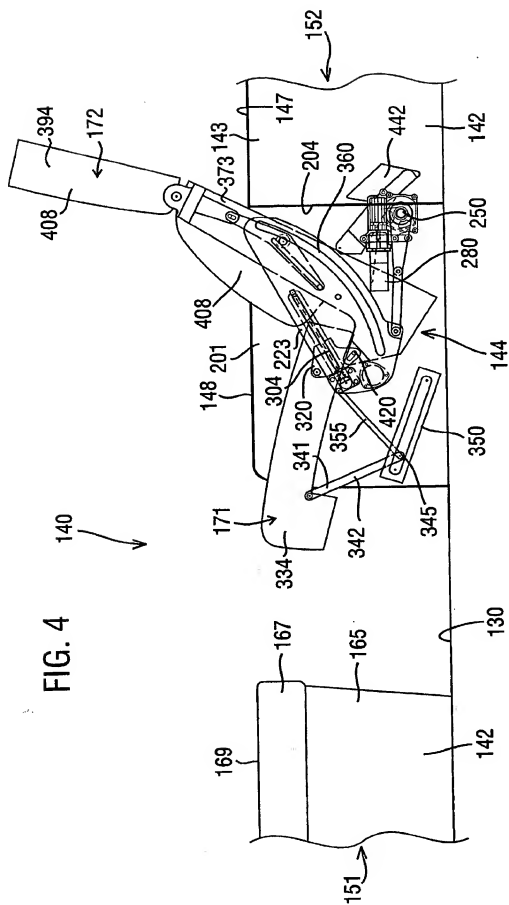


FIG. 4





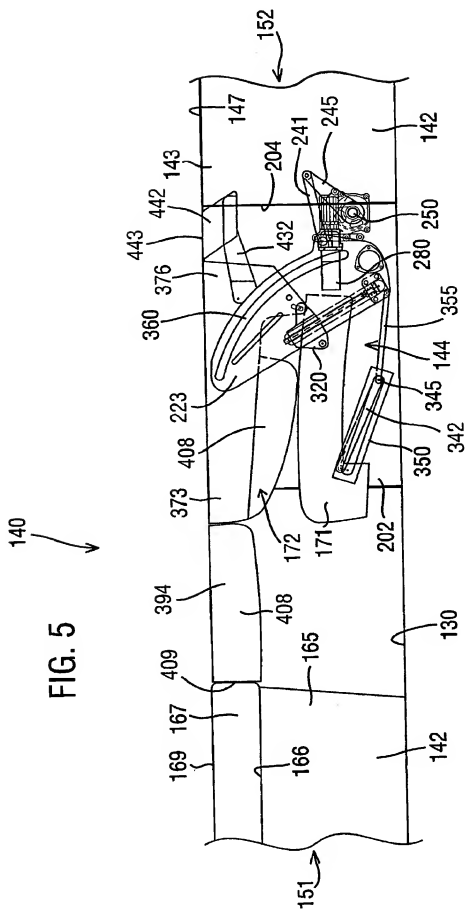


FIG. 6

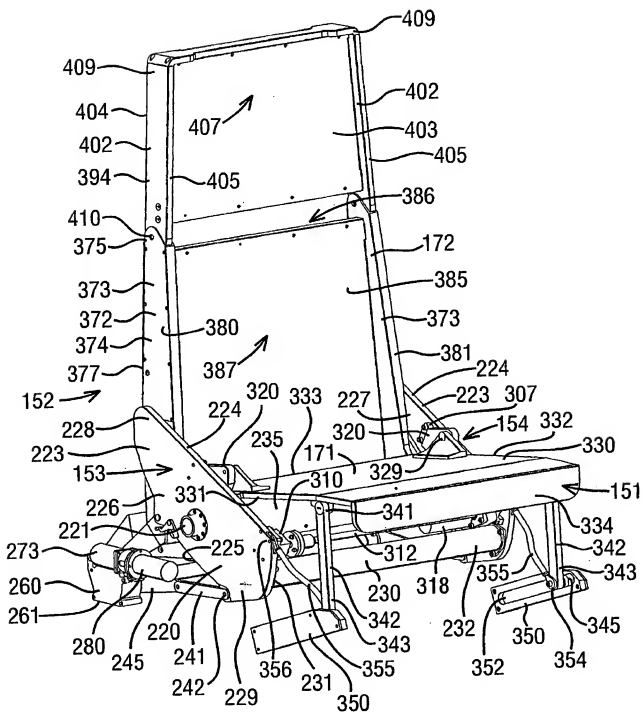


FIG. 6A

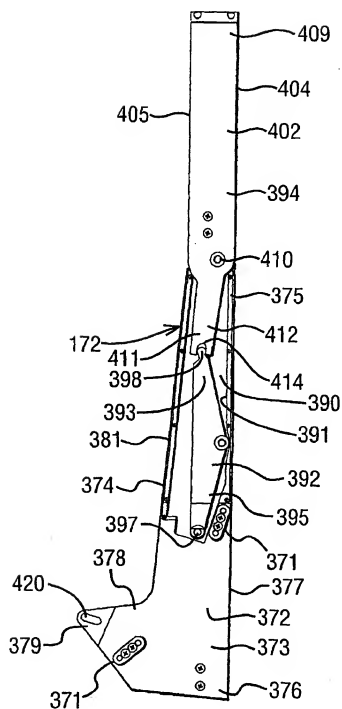


FIG. 6B

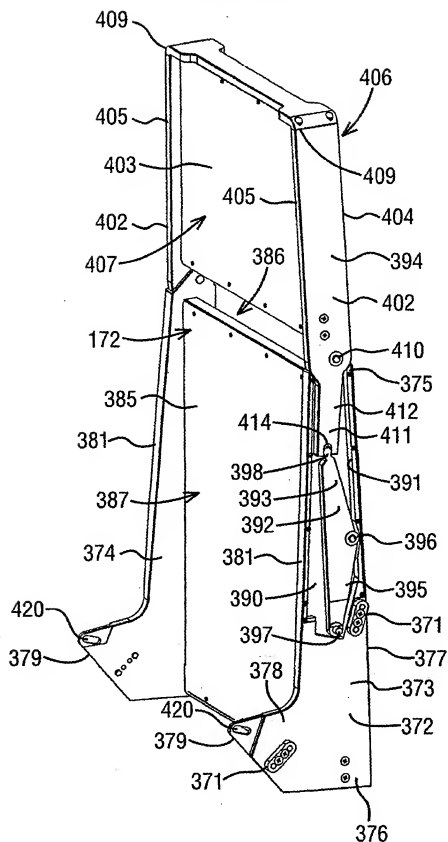


FIG. 7

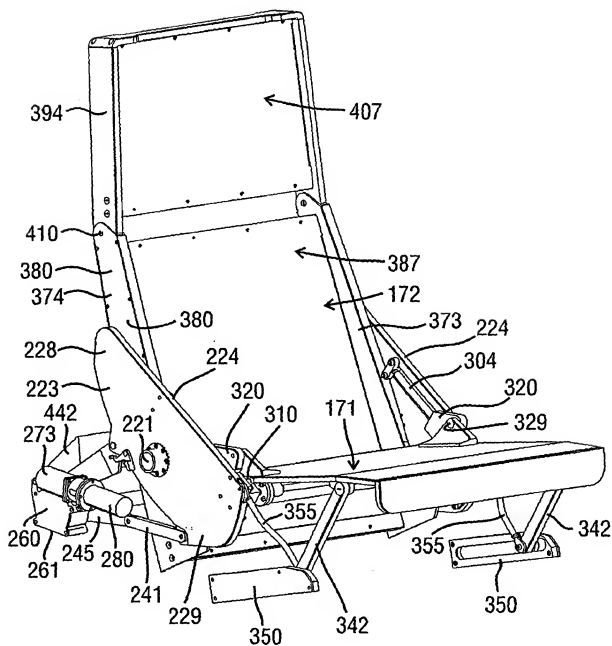


FIG. 8

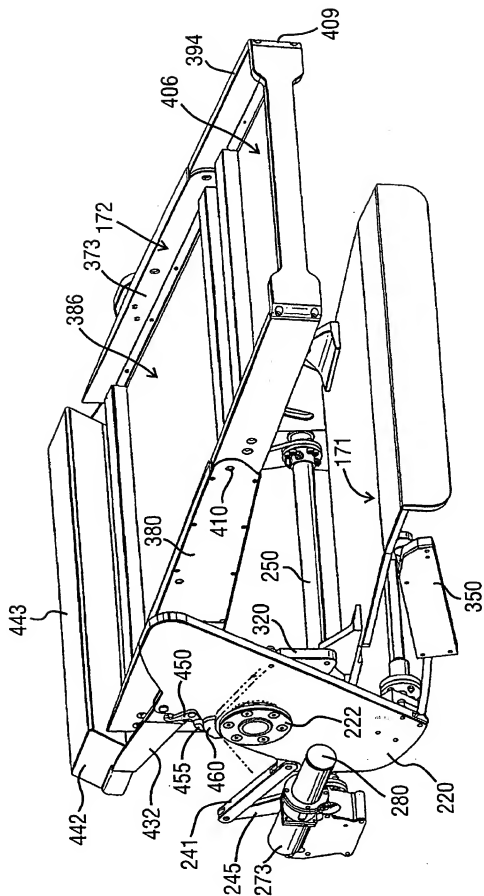
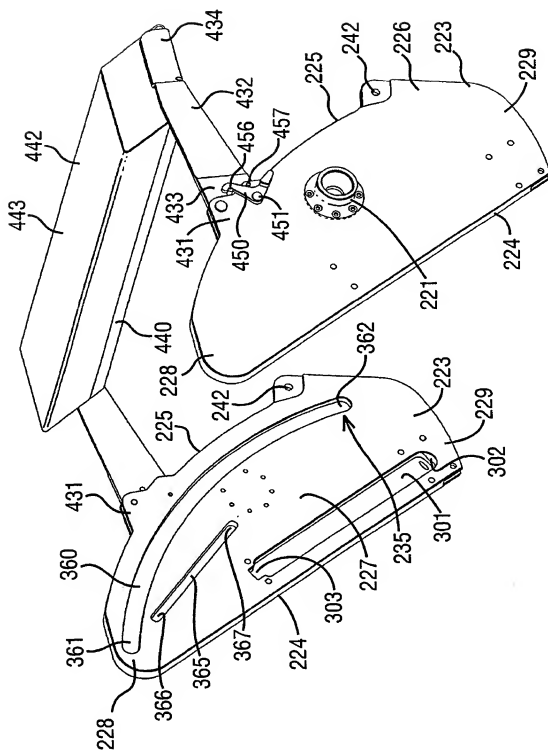
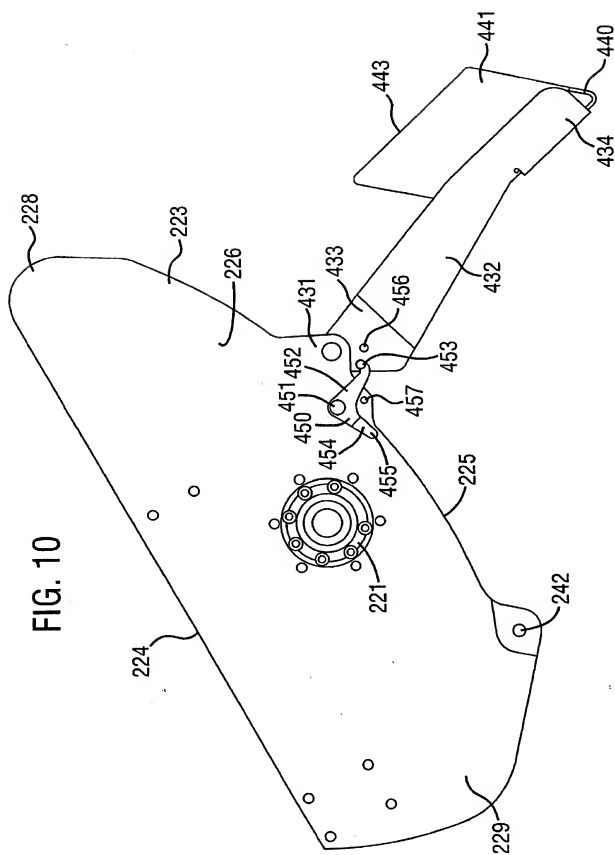


FIG. 9







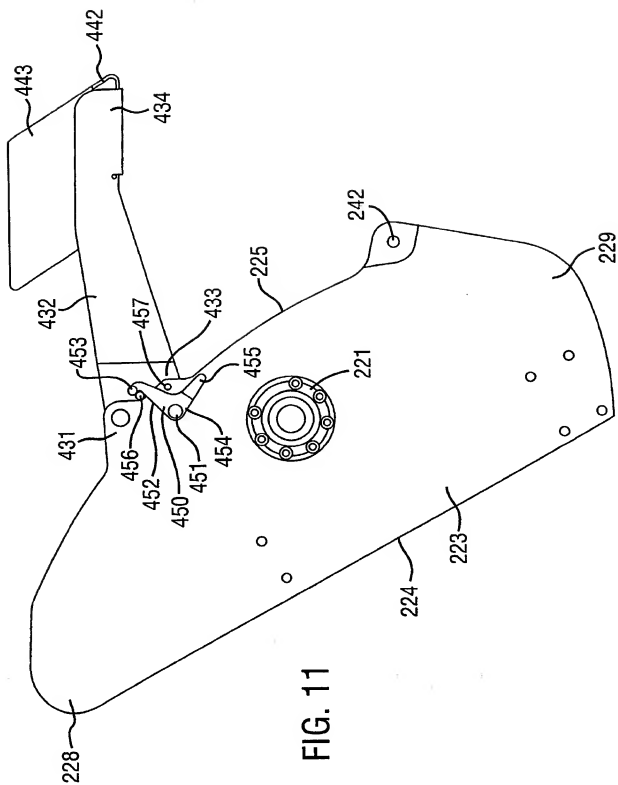


FIG. 11

FIG. 12

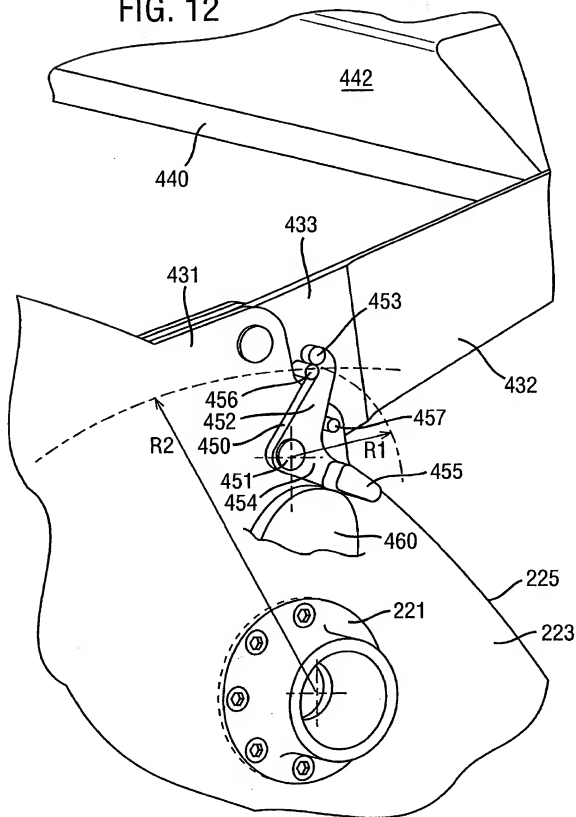


FIG. 13

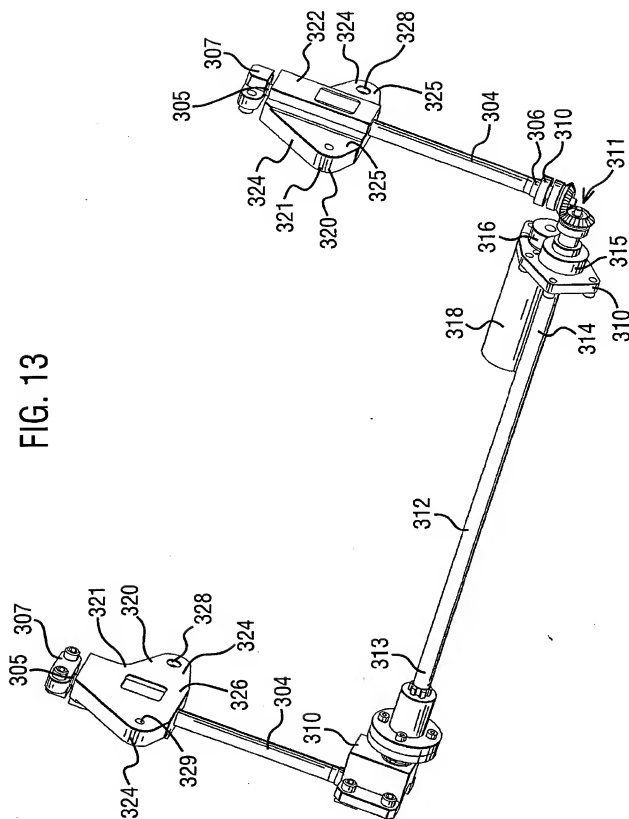
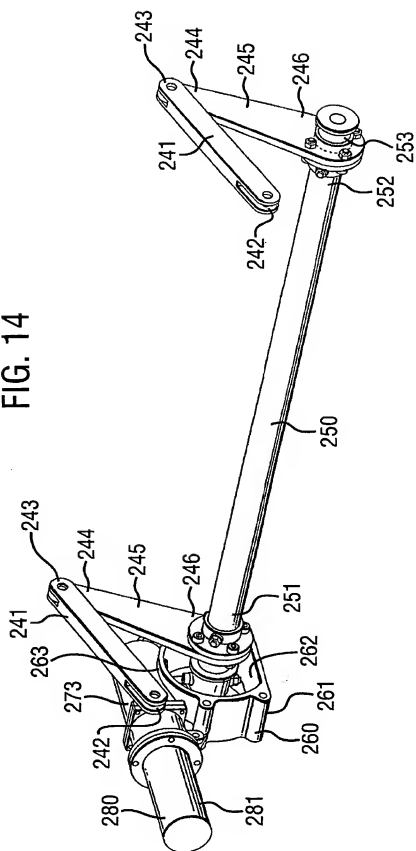


FIG. 14



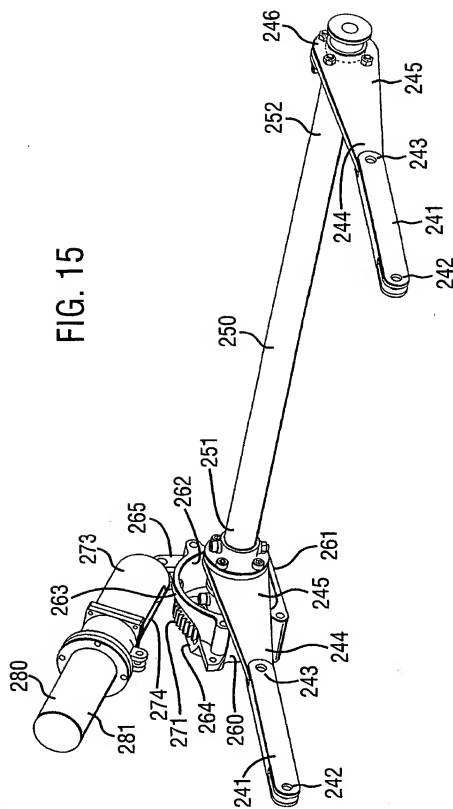


FIG. 16

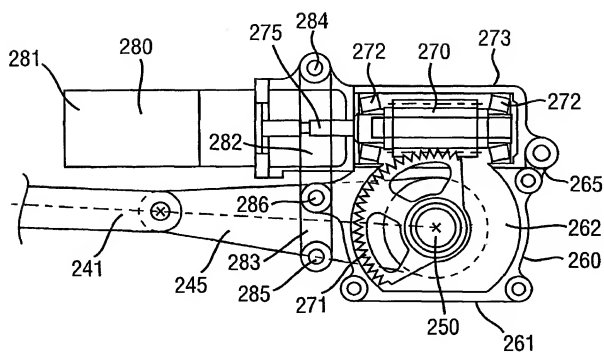


FIG. 17

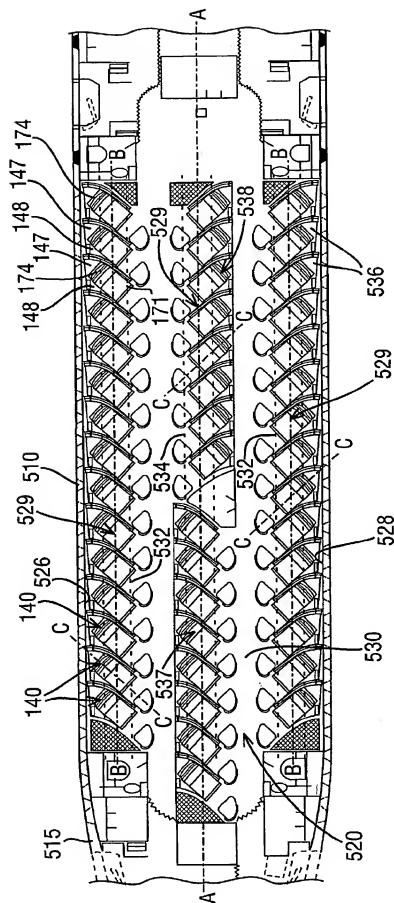


FIG. 18

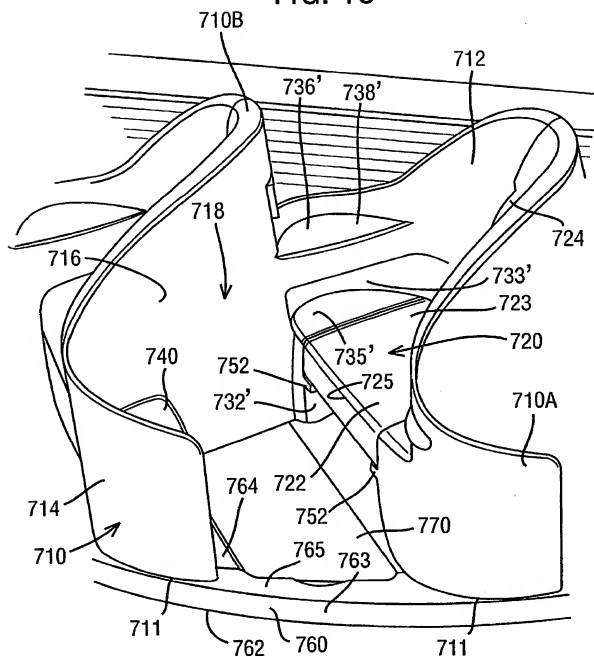




FIG. 19

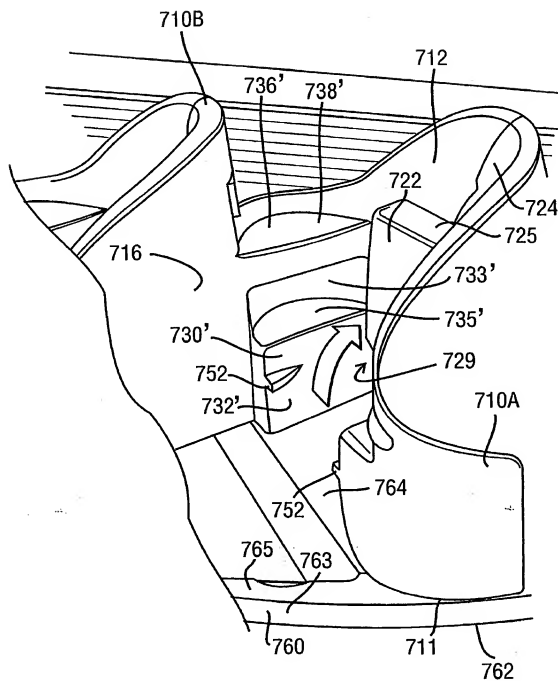




FIG. 21

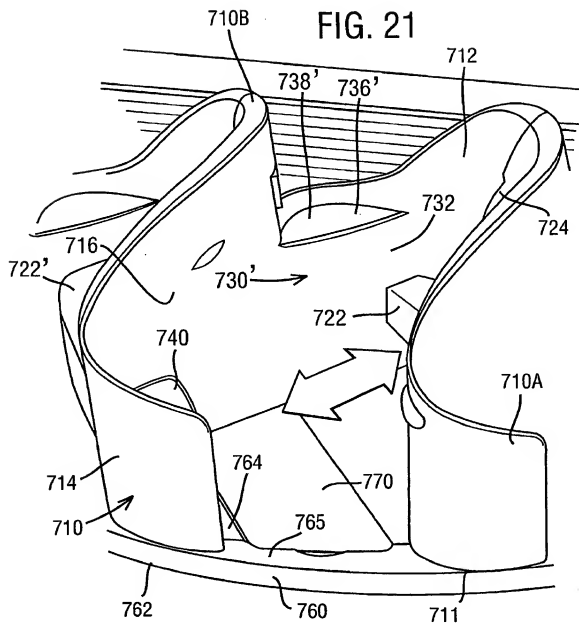


FIG. 22A

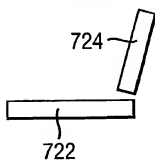


FIG. 22B

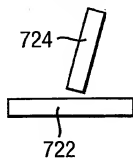


FIG. 22C

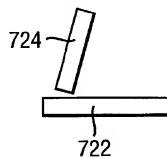
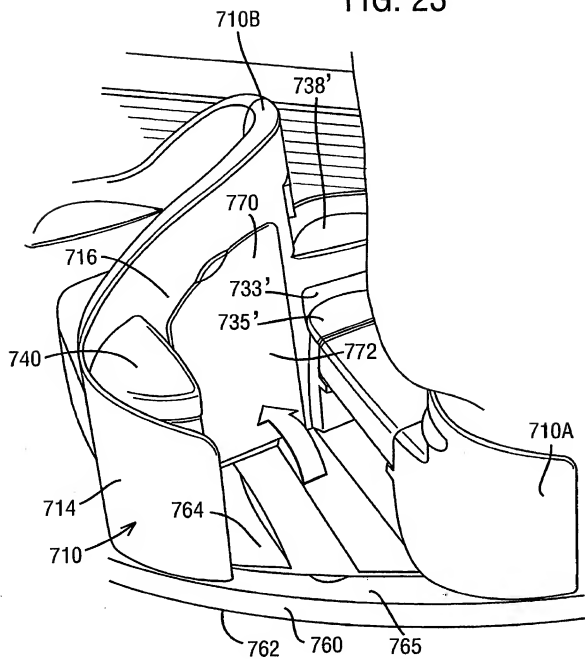
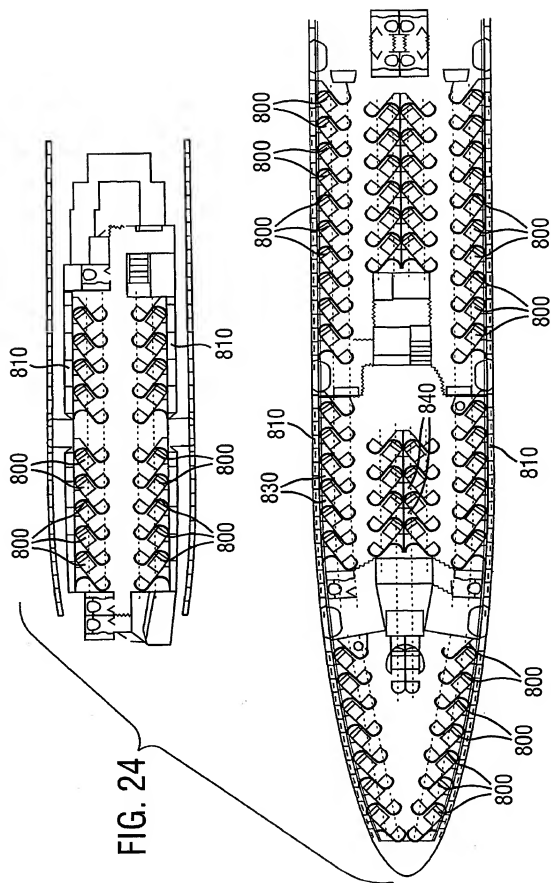


FIG. 23





European Patent  
Office

## EUROPEAN SEARCH REPORT

Application Number  
EP 04 10 1715

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X,P	GB 2 362 095 A (AMERICAN AIRLINES INC) 14 November 2001 (2001-11-14)	1,3,4, 6-9	B60N2/34 B64D11/06
A,P	* abstract; claims 1-48; figures 18,2,38 *	5,10,11	
A	DE 297 02 660 U (WESTFALIA-WERKE KNÖBEL GMBH & CO.) 15 May 1997 (1997-05-15) * page 4, line 1 - page 5, line 8 * * page 6, line 30 - page 7, line 27; figures 1,2,6-8 *	1,2,5	
A,D	GB 2 326 824 A (BRITISH AIRWAYS PLC) 6 January 1999 (1999-01-06) * abstract * * page 12, line 19 - page 16, line 12; claim 1; figures 1,9-11,13-17 *	1-11	
A,D	WO 00/21831 A (BRITISH AIRWAYS PLC) 20 April 2000 (2000-04-20) * abstract; claims 1,6-9; figures 1,2 *	1-11	
A,D	FR 647 809 A (M. CHARLES-HENRI-LEON HANIN) 1 December 1928 (1928-12-01) * the whole document *	1-11	TECHNICAL FIELDS SEARCHED (Int.Cl.7)  B60N B64D B61D
The present search report has been drawn up for all claims			
Place of search Berlin		Date of completion of the search 16 November 2004	Examiner Cuny, J-M
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPC FORM 1503 (03.02.98) (PAG.1/1)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 04 10 1715

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15-11-2004

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
GB 2362095	A	14-11-2001	NONE	
DE 29702660	U	15-05-1997	DE 29702660 U1	15-05-1997
GB 2326824	A	06-01-1999	GB 2331237 A ,B	19-05-1999
			AT 260800 T	15-03-2004
			AU 717706 B2	30-03-2000
			AU 3575499 A	19-08-1999
			AU 717708 B2	30-03-2000
			AU 3575599 A	19-08-1999
			AU 709431 B2	26-08-1999
			AU 3910295 A	20-06-1996
			AU 4182396 A	03-07-1996
			BR 9510008 A	21-10-1997
			CA 2165097 A1	14-06-1996
			CA 2389315 A1	14-06-1996
			CH 692979 A5	15-01-2003
			CH 692978 A5	15-01-2003
			CH 693534 A5	30-09-2003
			CN 1266799 A ,B	20-09-2000
			CN 1132711 A ,B	09-10-1996
			DE 19544754 A1	20-06-1996
			DE 69532644 D1	08-04-2004
			EP 1162138 A2	12-12-2001
			EP 0794897 A1	17-09-1997
			FI 972497 A	12-08-1997
			FI 20011825 A	17-09-2001
			FI 20040633 A	04-05-2004
			FR 2727932 A1	14-06-1996
			FR 2769286 A1	09-04-1999
			WO 9618537 A1	20-06-1996
			GB 2295962 A ,B	19-06-1996
			HK 1028221 A1	02-11-2001
			HK 1002312 A1	12-05-2000
			HK 1020432 A1	29-12-2000
			IT RM950813 A1	13-06-1996
			JP 8258796 A	08-10-1996
			NL 1001893 C2	13-06-1996
			NZ 297049 A	29-04-1999
			NZ 334165 A	29-06-1999
			NZ 334166 A	29-06-1999
			SG 33627 A1	18-10-1996
			TW 393418 B	11-06-2000
			US 6059364 A	09-05-2000
			US 2002017810 A1	14-02-2002
			ZA 9510537 A	19-06-1996

EPO Form P449

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 04 10 1715

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16-11-2004

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 0021831	A	20-04-2000	AU 770136 B2	12-02-2004
			AU 6221899 A	01-05-2000
			BR 9914556 A	12-03-2002
			CA 2347165 A1	20-04-2000
			CN 1114547 B	16-07-2003
			DE 19983643 T0	31-01-2002
			DK 200100603 A	31-05-2001
			EP 1121291 A2	08-08-2001
			FI 20010777 A	12-04-2001
			WO 0021831 A2	20-04-2000
			JP 2002527288 T	27-08-2002
			NO 20011877 A	13-06-2001
			NZ 511409 A	31-10-2003
			SE 518892 C2	03-12-2002
			SE 0101337 A	17-05-2001
FR 647809	A	01-12-1928	NONE	
JP 05013838	A	22-01-1993	DE 69200180 01	14-07-1994
			DE 69200180 T2	12-01-1995
			EP 0521715 A1	07-01-1993
			US 5291508 A	01-03-1994

EPO.COM/PO4

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82